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OILS AND VARNISHES.

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PREFACE.

IN the preparation of this volume, the information in COOLEY'S "Cyclopædia" has been supplemented from the latest publications, with the object of producing a handbook useful to all interested in Oils and Varnishes, and especially to analysts, pharmacists, manufacturers, and technological students. The Editor desires to express his indebtedness to Mr. W. H. BAILEY, of Salford, for his revision of the section dealing with the lubricating qualities of oils.

J. C.

LONDON, *April* 1886.

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OILS AND VARNISHES.

CHAPTER I.

CHEMISTRY OF OILS.

OILS are a numerous class of bodies widely distributed in each of the three kingdoms of Nature. Under the term "oil" we include not only certain well-known liquid and solid compounds occurring in, or derived from, animals and plants, but also the rock oils or petroleums, peat oils, shale oils, and coal-tar oils.

Oils from animal and vegetable sources have been known and used extensively from the earliest times, and springs of mineral oils have been known in several localities from time immemorial, but it is only recently that the last have acquired great general importance.

When any oily body is dropped or spread upon paper, it produces a greasy stain. On warming, in the case of some oils, this stain entirely disappears, while in other cases, after the application of heat, the stain still remains. The former distil without decomposition; the latter do not. By this difference of behaviour all oils may be divided into two classes, *volatile* and *fixed*. The animal and vegetable kingdoms each afford examples of both fixed and volatile oils, but mineral oils are all volatile.

Nearly all the fixed oils, when exposed to the air, absorb oxygen rapidly, and either gradually harden or become nauseous and rancid. From the former are selected the "drying" oils used by painters, and the latter are used as food, in cookery, and for machinery, lamps, &c.

Some of the fixed oils, especially linseed, rape, and olive oils, when absorbed by porous substances and thus freely exposed to the atmosphere, unite with oxygen so rapidly as to generate a considerable degree of heat. Hence paper, tow, cotton-waste, wool, shoddy, hemp, straw, shavings, &c., if slightly soaked with such oils and left in a heap, often spontaneously inflame.

The specific gravity of oils fluctuates a little on either side that of water—fixed animal and vegetable oils in this respect varying from 0·860 to 0·970 at 60° Fahr. (15·5° Cent.), volatile animal and vegetable oils from 0·847 to 1·096, and mineral oils from 0·800 to 1·100—water being 1·000.

I. Chemistry of the Fixed Oils (*Animal and Vegetable*).

Animal and vegetable oils and fats are salts of glycerin with organic acids, or, more accurately, are "mixtures of ethereal salts formed from glycerin and acids of the acetic and oleic series" (Armstrong).

By "ethereal salt" we understand a compound derived from the union of an organic base with either a mineral oxy-acid, or an organic acid. Thus common alcohol, an organic base, and acetic acid, an organic acid, produce an "ethereal salt" called *acetic ether* (*ethylic acetate*) thus:—

$$\underbrace{CH_3CO.OH}_{\text{Acetic acid}} + \underbrace{C_2H_5.OH}_{\text{Alcohol}} = \underbrace{CH_3CO(OC_2H_5)}_{\text{Acetic ether}} + \underbrace{OH_2}_{\text{Water}}$$

It will help to make the chemical constitution of these oils clear if we consider (1°) glycerin itself, the organic base, then (2°) the organic acids, and lastly (3°) glance at the manner in which we find them naturally united together in the oils.

(1°) **Glycerin.**—$C_3H_5(OH)_3$.—Pure glycerin is a colourless, viscid liquid of specific gravity 1·27 or 1·28. Its taste is intensely sweet, and it is miscible in all proportions with water. It is unfermentable, and has no action on vegetable colours. In presence of aqueous vapour, under pressure in air, and *in vacuo*, it can be distilled, but it decomposes when heated in air at the ordinary pressure, with production of *acroleïn*, which has a well-known peculiarly penetrating odour. It boils *in vacuo* at 179·5° (C.). It is represented by the formula given above, or thus: $C_3H_5\left\{\begin{matrix}OH\\OH\\OH\end{matrix}\right.$; and is classed as a tri-hydric, tri-atomic, or tri-valent alcohol According to Werner,[*] commercial glycerin may be made to crystallize by passing a few bubbles of chlorine into it. When acted on slowly by *dilute* nitric acid, it is converted into glyceric or glycerinic acid, thus:—

$$\underbrace{C_3H_5(OH)_3}_{\text{Glycerin}} + \underbrace{O_2}_{\text{Oxygen}} = \underbrace{C_3H_3O(OH)_3}_{\text{Glyceric acid}} + \underbrace{OH_2}_{\text{Water}}$$

H_2 being exchanged for O. Glyceric acid thus stands in the same relation to glycerin that acetic acid does to ordinary ethyl alcohol.

If the nitric acid employed be concentrated, instead of dilute, another compound called glyceric trinitrate (trinitrin, trinitroglycerin, or nitroglycerin) is formed. This consists of glycerin with 3 atoms of H replaced by NO_2, thus:—

---

[*] "Zeitschr. f. Chem." [2] iv. 413.

$$\underbrace{C_3H_5\left\{\begin{array}{l}OH\\OH\\OH\end{array}\right.}_{\text{Glycerin}} \qquad \underbrace{C_3H_5\left\{\begin{array}{l}O(NO_2)\\O(NO_2)\\O(NO_2)\end{array}\right.}_{\text{Nitroglycerin}}$$

Nitroglycerin is thus an ethereal salt formed by union of glycerin with a mineral oxyacid. It explodes violently on percussion, but it may be rendered non-explosive by mixture, or dilution, with ordinary wood spirit, and when required for use may afterwards be recovered by adding water to the mixture, whereby the nitroglycerin is precipitated. When mixed in the proportion of 75 parts to 25 parts of an infusorial earth known as "Kieselghur," it forms NOBEL's dynamite.

(2°) The following are the most important organic acids met with in oils and fats, and belong either (a) to the acetic or fatty series of the general formula $C_nH_{2n+1}.CO(OH)$, or (β) to the acrylic or oleic series having the general formula $C_nH_{2n-1}.CO(OH)$.

(a) *Acetic or* $C_nH_{2n+1}.CO(OH)$ *Series.*

Name.	Formula.	Fusing point (Cent.).	Boiling point (Cent.).
Butyric acid	$C_3H_7.CO(OH)$	Below – 20°	163°
Valeric ,, ...	$C_4H_9.CO(OH)$	,, 0°	184·5°
Caproic ,, ...	$C_5H_{11}.CO(OH)$	– 2°	205°
Œnanthylic ,, ...	$C_6H_{13}.CO(OH)$	– 10·5°	223·5°
Caprylic ,, ...	$C_7H_{15}.CO(OH)$	14°	236°
Pelargonic ,, ...	$C_8H_{17}.CO(OH)$	12°	253·5°
Capric ,, ...	$C_9H_{19}.CO(OH)$	30°	
Cocinic ,, ...	$C_{10}H_{21}.CO(OH)$	35°	
Lauric ,, ...	$C_{11}H_{23}.CO(OH)$	40·5°	
Myristic ,, ...	$C_{13}H_{27}.CO(OH)$	53·8°	
Palmitic ,, ...	$C_{15}H_{31}.CO(OH)$	62°	
Margaric ,, ...	$C_{16}H_{33}.CO(OH)$	59·9°	
Stearic ,, ...	$C_{17}H_{35}.CO(OH)$	69·2°	
Arachidic ,, ...	$C_{19}H_{39}.CO(OH)$	75°	
Behenic ,, ...	$C_{21}H_{43}.CO(OH)$	76°	
Cerotic ,, ...	$C_{26}H_{53}.CO(OH)$	78°	
Melissic ,, ...	$C_{29}H_{59}.CO(OH)$	88°	

(β) *Acrylic or* $C_nH_{2n-1}.CO(OH)$ *Series.*

Name.	Formula.	Name.	Formula.
Oleic acid	$C_{17}H_{33}.CO(OH)$	Doeglic acid	$C_{19}H_{36}O_2$
Elaïdic „	$C_{17}H_{33}.CO(OH)$	Brassic or Erucic „	$C_{22}H_{42}O_2$
Linoleic „	$C_{16}H_{28}O_2$		
Ricinoleic „	$C_{18}H_{34}O_3$		

Butyric Acid.—*Syn.* TETRYLIC ACID, $C_3H_7.CO(OH)$.—This acid was first obtained by CHEVREUL in the course of his elaborate investigations on oils. It occurs in combination with glycerin in butter; in the free state in juice of flesh, in sweat, and in many animal secretions. It may be prepared by fermentation of sugar with putrid cheese. It is a thin, colourless liquid, of pungent, rancid odour and sour taste. It is miscible in all proportions with alcohol, ether, and *cold* water. Its specific gravity is 0·958 at 57·2° F. (14° C.).

Valeric Acid.—*Syn.* PENTYLIC ACID, $C_4H_9.CO(OH)$.—There are four isomeric acids of this name. The ordinary valeric or valerianic acid occurs in valerian and angelica roots, and in the berries and bark of Guelder rose (*Viburnum opulis*). It has an odour like decayed cheese. It has specific gravity of 0·947 at 32° F. (0° C.).

Caproic Acid—*Syn.* HEXYLIC ACID, $C_5H_{11}.CO(OH)$—exists, in combination, in butter-fat and cocoa-nut oil, and, in the free state, in perspiration. It also occurs together with butyric and valeric acids in the flowers of *Satyrium hircinum*, which have the odour of bugs. It is a colourless, oily liquid, with a feeble odour. It is soluble in alcohol, ether, and *boiling* water. Its specific gravity is 0·938.

Œnanthylic Acid.—*Syn.* HEPTYLIC ACID, $C_6H_{13}CO(OH)$.—Met with in castor oil. It is an oily liquid, of specific gravity 0·9345 at 32° F. (0° C.).

Caprylic Acid—*Syn.* OCTYLIC ACID, $C_7H_{15}.CO(OH)$—occurs in butter, cocoa-nut oil, fusel oil, and putrid yeast. It has a strong odour of sweat. Its specific gravity is 0·911. It is difficultly soluble even in *boiling* water, from which it crystallizes in needles or plates easily soluble in alcohol and benzene.

Pelargonic Acid—*Syn.* NONYLIC ACID, $C_8H_{17}.CO(OH)$—exists ready formed in leaves of the geranium (*Pelargonium roseum*). Its odour is somewhat disagreeable. Its specific gravity is 0·9065 at 17° C. (62·6° F.).

Capric Acid.—*Syn.* DECYLIC ACID, $C_9H_{19}.CO(OH)$.—Called also RUTIC ACID. Like caprylic, this acidis present in butter, cocoa-nut oil, fusel oil, and in all fats which contain caproic and caprylic acids. It has a faint, goat-like smell. It is sparingly soluble even in hot water, but soluble in alcohol and ether. With butyric, caproic, and caprylic, it forms the four chief volatile acids of butter-fat.

Cocinic Acid.—*Syn.* COCO-STEARIC ACID, $C_{10}H_{21}.CO(OH)$.—BROMEIS* obtained from cocoa-nut fat an inodorous fatty acid which melted at 35° C., and distilled without decomposition. It was also separated by ST. EVRE from cocoa-nut oil, and has since been separated from spermaceti by HEINTZ, from Chaulmoogra oil by NAYLOR and MASS, and from the fat extracted from the nuts of the California bay-tree by SHILLMAN and O'NEILL, who called it *umbellulic acid.*† It is considered that all these are cocinic acid.

Lauric Acid—$C_{11}H_{23}.CO(OH)$—occurs in the berries of the bay-tree (*Laurus nobilis*), in cocoa-nut oil, spermaceti, and other fats. Insoluble in water. Crystallizes from alcohol and ether in white silky needles, melting at 110·5° F. (43·6° C.).

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* "Ann. Ch. Pharm." xxxv. 277.

† "J. Soc. Chem. Ind." 1883, 57.

Myristic Acid—$C_{13}H_{37}.CO(OH)$—can be obtained by saponification from the white solid portion of the expressed oil of nutmegs, which is insoluble in cold alcohol. Combined with glycerin, it forms the chief part of muscat fat (the fat of the fruit of *Myristica moschata*), and is especially abundant in dika-bread (the fruit of an African tree, *Mangifera gabonensis*). In small quantity it is also present in butter, cocoa-nut oil, and spermaceti. It is soluble in alcohol, but insoluble in water and ether. It crystallizes in shining laminæ.

Palmitic Acid—$C_{15}H_{31}.CO(OH)$—is a constituent of nearly all animal and vegetable fats. In solid animal fats it occurs chiefly with stearic acid, whilst in vegetable oils it is chiefly associated with oleic acid. Palm oil contains it in large quantity. It is a colourless, odourless, and tasteless solid, insoluble in water, cold or hot, but soluble in alcohol and ether, yielding acid solutions. It crystallizes in tufts of slender needles. It may be distilled almost without change.

Margaric Acid—$C_{15}H_{33}.CO(OH)$—resembles stearic acid very closely. It is, however, more soluble in alcohol, and has a lower melting point (see table, p. 4). The researches of HEINTZ have thrown doubts on its existence naturally. HEINTZ considers it as a mixture of stearic acid with lower acids of the series, chiefly palmitic. It can, however, be prepared artificially by displacing the OH group in cetylic alcohol ($C_{16}H_{33}.OH$) by CO(OH).*

Stearic Acid—$C_{17}H_{35}.CO(OH)$—is now an article of commerce. When pure, it crystallizes in milk-white needles, which are soluble in ether and in cold alcohol. The commercial acid, which contains also some palmitic acid, is made into "stearin" candles. It is present in most fats, but in largest quantity in beef and mutton suet. It expands very much when heated, especially at its melting point.

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* "Pogg. Ann." cii. 272.

Arachidic Acid—$C_{19}H_{39}.CO(OH)$—occurs in oil of earth-nut (*Arachis hypogæa*). Crystallizes from alcohol in small bright scales, melting at 167° F. (75° C.).

Behenic Acid—$C_{21}H_{43}.CO(OH)$—is met with in ben oil, obtained from fruit of *Moringa*. It is crystalline, and melts at 168·8° F. (76° C.).

Cerotic Acid—$C_{26}H_{53}.CO(OH)$—is the largest constituent of that portion of bees'-wax which is soluble in boiling alcohol, and occurs also largely in Chinese wax. It may be distilled unchanged. It is a white, crystallizable substance, soluble in 16 parts of boiling alcohol. It greatly resembles white wax, of which, indeed, it forms from 70 to 80 per cent. It is sometimes called *cerin.*

Melissic Acid—$C_{29}H_{59}.CO(OH)$—occurring in bees'-wax, can be obtained by heating myricylic alcohol with potash-lime. It closely resembles cerotic acid, but melts at 192° F. (89° C.).

Oleic Acid.—*Syn.* ELAIC ACID, $C_{17}H_{33}.CO(OH)$.—This acid is very widely distributed, being present in most natural fats and fixed "non-drying" oils. It constitutes about 30 per cent. of butter-fat. Almond, olive, and whale oils are especially rich in it. It was discovered by CHEVREUL in 1811, and its formula established by GOTTLIEB in 1846. It is a tasteless, colourless, odourless, oily acid, insoluble in water, but soluble in alcohol, ether, and oil. Commercially it is prepared from the crude acid obtained in the purification of stearic acid, forming an important secondary product of that operation. It crystallizes from alcohol in white needles, melting at 57·2° F. (14° C.) and solidifying at 39·2° F. (4° C.). It volatilizes *in vacuo* without decomposition. Cold concentrated sulphuric acid dissolves it undecomposed.

Perfectly pure oleic acid may be obtained as follows:—

1. By saponifying olein.

2. Pure almond or olive oil soap is decomposed by a dilute acid, and the resulting oily acid is digested in a water bath with half its weight of litharge (in very fine powder) for some hours, constantly stirring; the mixture is then agitated with twice its volume of ether in a close vessel, and in twenty-four hours the clear ethereal solution is decanted, and decomposed with dilute hydrochloric acid; the oleic acid separates, and the ether mixed with it is expelled by evaporation. To render it colourless, the acid is again saponified with caustic soda, and the soap thus retained is repeatedly dissolved in a solution of soda, and as often separated by adding common salt; this soap is, lastly, decomposed by dilute hydrochloric acid, as before.

3. (H. N. Fraser, pharmacist.) Oil of cotton seeds ("winter oil"), deprived of most of its stearin by chilling and pressure, is first saponified with potassa, using a slight excess of the base. The soap is then treated with tartaric acid, or any other acid which will make a soluble salt with potassa, until the base is completely neutralized; the residue is washed until a mass is left about the consistence and colour of cerate, free from any of the salt; this is heated for several hours with nearly its weight of litharge, and three or four times its bulk of water; the resulting compound is shaken up while yet warm with ether, and allowed to stand until all the soluble matter separates.

This separates the stearate, and leaves a nearly pure oleate of lead. The clear liquor is decanted and briskly shaken with dilute muriatic acid for a few minutes to precipitate all the chloride of lead, the lighter liquid washed to remove traces of muriatic acid and filtered; the filtrate heated slowly in a water bath, and the ether distilled until the residue ceases to have an ethereal odour. The product is about 50 per cent. of the bulk of the oil.

Crude oleic acid may be purified as follows:—Expose it repeatedly to a temperature of about 45° F., and express the liquid portion. With this mix an equal bulk of solution of sulphurous acid, place the mixture in the light, and shake it frequently until no more colour is discharged. After separation, the oleic acid is to be washed repeatedly with cold distilled water, and put into bottles, which should be kept filled up and in a cool place.

Elaïdic Acid.—$C_{17}H_{33}.CO(OH)$.—When nitrous anhydride (N_2O_3) or nitrous acid (HNO_2) is passed into liquid oleic acid, the latter is converted into elaïdic acid, a solid compound isomeric with oleic acid. It is a crystalline body, melting at about 113° F. (45° C.). When nitrous acid acts on olein, or an oil containing olein (*i.e.*, glycerin in combination with oleic acid), instead of elaïdic acid, the solid product is called elaïdin (*i.e.*, glycerin in combination with elaïdic acid). Almond, olive, and castor oils thus yield a large proportion of elaïdin, but the "drying oils," such as those of linseed, poppy, walnuts, &c., refuse to solidify. Elaïdic acid is a far more stable body than oleic acid, and may be distilled in air in a great measure unchanged.

Ricinoleic Acid—*Syn.* HYDROXYOLEIC ACID, $C_{18}H_{34}O_3$—has not been thoroughly studied. It is said to be the essential constituent of castor oil, and to stand in near relationship to oleic acid.

Linoleic Acid is supposed by some to be the characteristic acid in union with glycerin in the "drying oils," hemp, linseed, poppy, &c., and has received the formula $C_{16}H_{28}O_2$. Its specific gravity is 0·9206 at 14° C.

Doeglic Acid.—$C_{19}H_{36}O_2$.—This is very similar to oleic acid. SCHARLING states that he has found it in the oil of the bottle-nosed whale (doegling), and that it forms an ethereal salt analogous to spermaceti.

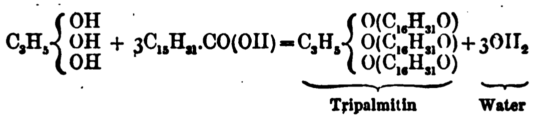
Brassic Acid. — *Syn.* ERUCIC ACID, $C_{22}H_{42}O_2$. — This occurs in combination in rape or colza oil and in oil of mustard seed. It crystallizes in thin white needles, melting at about 91° F. (33–34° C.). Nitrous anhydride (N_2O_3) is without action on it.

(3°) When glycerin is combined with any of the foregoing acids, the resulting compound is called a *glyceride*, but there is no oil or fat known which is made up of glycerin in union with one only of these acids. An oil or fat generally consists of glycerides containing several of the members of the above series of acids. The glyceride containing palmitic acid is called *palmitin*, that containing stearic acid is called *stearin*. Glycerin and oleic acid form *olein*, and glycerin and butyric acid form *butyrin*. Such combinations may be effected experimentally by heating glycerin with the organic acid in closed vessels. The proportions in which they unite under this treatment vary according to the original proportions of the mixture operated upon, the temperature employed, and the length of time during which the heat is applied. We are indebted to M. Berthelot for much information on this subject. He has succeeded in combining glycerin with a great number of acids, and has produced artificially many compounds—some analogous to natural fats, others chemically identical with them. Thus, to take one example out of many, M. Berthelot has produced *three* compounds of glycerin with palmitic acid, as follows:—

$$(a)\quad \underbrace{C_3H_5\left\{\begin{array}{l}OH\\OH\\OH\end{array}\right.}_{\text{Glycerin}} + \underbrace{C_{15}H_{31}.CO(OH)}_{\text{Palmitic acid}} = \underbrace{C_3H_5\left\{\begin{array}{l}O(C_{16}H_{31}O)\\OH\\OH\end{array}\right.}_{\text{Monopalmitin}} + \underbrace{OH_2}_{\text{Water}}$$

$$(\beta)\quad \underbrace{C_3H_5\left\{\begin{array}{l}OH\\OH\\OH\end{array}\right.}_{\text{Glycerin}} + \underbrace{2C_{15}H_{31}.CO(OH)}_{\text{Palmitic acid}} = \underbrace{C_3H_5\left\{\begin{array}{l}O(C_{16}H_{31}O)\\O(C_{16}H_{31}O)\\OH\end{array}\right.}_{\text{Dipalmitin}} + \underbrace{2OH_2}_{\text{Water}}$$

(γ)



$$C_3H_5\left\{\begin{array}{l}OH\\OH\\OH\end{array}\right. + 3C_{15}H_{31}.CO(OH) = \underbrace{C_3H_5\left\{\begin{array}{l}O(C_{16}H_{31}O)\\O(C_{16}H_{31}O)\\O(C_{16}H_{31}O)\end{array}\right.}_{\text{Tripalmitin}} + \underbrace{3OH_2}_{\text{Water}}$$

Similarly we may have mono-, di-, and tri- stearin, &c. Naturally we only find tripalmitin, tristearin, triolein, &c., the mono- and di- compounds being all artificial. It has been usual to consider oils as *mixtures* of these ethereal salts, but the researches on butter of Dr. James Bell, F.R.S., of the Government Laboratory, Somerset House, tend to show that their nature is by no means so simple. In "The Analysis and Adulteration of Foods," part ii. p. 44, Dr. Bell says: "As butter-fat contains several members of the fatty acid series, it is not unreasonable to expect that in the same molecule there would be found, not three combining quantities of the same acid, but possibly three different acids, forming a triacid compound as follows:—

$$\left.\begin{array}{l}\text{Oleic acid}\\\text{Palmitic acid}\\\text{Butyric acid}\end{array}\right\}\text{Glycerin.}$$

When ordinary animal fat is melted and mixed with butyrin or tributyrate of glycerin, $(C_4H_7O_3)C_3H_5O_3$, the latter compound is entirely removed by treatment with warm alcohol, and the animal fat is recovered in practically the same condition as before the admixture. When, however, butter-fat is treated with hot alcohol, from 2 to 3 per cent. only of its weight is dissolved. This does not consist, as might be supposed, of compounds of glycerin with butyric and caproic acids, but of a fat which is liquid at 60° F. (15·5° C.), and yields on saponification from 13 to 14 per cent. of soluble fatty acids and from 79 to 80 per cent. of insoluble fatty acids. The low melting point of the extracted fat does not arise from an increased proportion of oleic acid, as the insoluble acids obtained after saponification have a higher melting point than the mixed insoluble acids obtained from the butter-fat. These results closely agree with a compound of the following composition :—

$$\left.\begin{array}{l} C_{18}H_{33}O \\ C_{16}H_{31}O \\ C_4H_7O \end{array}\right\} C_3H_5O_3,$$

that is, oleo-palmito-butyrate of glycerin."

II. Chemistry of the Volatile Oils (*Vegetable and Mineral*).

None of these oils can be termed "fats." Their chemical composition is quite different from that of the "fixed" oils or fats.

(1°) **Vegetable Oils.**—The volatile oils obtained from plants are variously designated as *essential oils*, *essences*, *ethereal oils*, *distilled oils*. They chiefly consist of carbon and hydrogen, and are chemically classed as hydrocarbons of the C_nH_{2n-4} series, or *terpenes*, *n* atoms of carbon being associated with 2_{n-4} atoms of hydrogen. The oils of this class best known have all the composition of common oil of turpentine, or $C_{10}H_{16}$. Besides carbon and hydrogen, however, there are present in these substances varying, but smaller, proportions of oxygen, nitrogen, and sulphur. Many of the compounds containing oxygen are solids dissolved in the oil, and often separating therefrom in a crystalline form. Such solid portions are often called *stearoptenes*, and are represented by such formulæ as $C_{10}H_{14}O$, $C_{10}H_{16}O$, $C_{10}H_{18}O$. The fluid portion of an oil yielding a *stearoptene* is called *elæoptene*.

These oils thus are, chemically, divisible into three classes, containing

(*a*) Carbon and hydrogen only;

(β) Carbon and hydrogen + oxygen ;

(γ) Carbon and hydrogen + sulphur or nitrogen.

(2°) **Mineral Oils.**—Like the vegetable volatile oils, these are composed of carbon and hydrogen. Chemically they are classed as hydrocarbons of the C_nH_{2n+2} or marsh-gas series, and, from a well-known and important member of the series, are also generically known as *paraffins*, a term which was proposed for these bodies by Mr. WATTS to indicate the chemical indifference which characterizes the entire group.* They are fully *saturated* compounds, and hence have no tendency to enter into combination with any other substances. At ordinary temperatures they are scarcely affected by strong acids, such as fuming nitric or concentrated sulphuric acids. Shale oils contain also hydrocarbons of the ethylene series, having the general formula C_nH_{2n}.

Sources.—In plants, oily substances are met with chiefly in the seed, more rarely in the bark, root, or other parts. It is only in the olive that oil is found in the fleshy integument of the fruit. In seeds it does not occur in the plumule or radicle, but only in that part from which the cotyledons arise. The seeds of plants belonging to the natural order *Cruciferæ* are the richest of all in oil, and next in oil-producing value are plants belonging to the natural orders *Drupaceæ*, *Amentaceæ*, and *Solaneæ*.

In animals, oil or fat occurs in the cellular tissue between the skin and flesh, among the fibres of muscle, in the membrane covering the intestines, and in the region of the kidneys. Butter-fat occurs naturally as an oil in the milk of the mammalia. In the whale the fat known as spermaceti is found in a bony cavity in the head.

The mineral oils, petroleums, rock oils, or naphthas are met with ready formed in certain geological strata in many parts of the world, while peat oils, shale oils, and coal-tar oils are obtained artificially by the distillation of peat, bituminous shales, and coal-tar respectively.

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* Paraffin = *parum*, little, and *affinis*, related to.

In considering these various substances it will be convenient to arrange them in three classes, according to their origin:—I. Animal oils; II. Vegetable oils; III. Mineral oils.

CHAPTER II.

ANIMAL OILS.

(a) fixed; (b) volatile.

UNDER this head we have three natural divisions according to the origin of the oil:—

A. Animal oils (proper).
B. Fish oils.
C. Insect oils.

A. ANIMAL OILS.

The most important, or interesting, fixed and volatile animal oils are the following:—

(a) *Fixed Animal Oils.*

Butter-fat.—This is the oily portion of the milk of mammals, but the name butter is generally restricted to that obtained from the milk of the cow.

The method of extracting butter from the liquid in which it naturally occurs varies in different countries, but the object is always to cause the coalescence of the fat globules, and this is effected by the simple operation of churning. The chief objects to be attended to in this operation are the maintenance of a proper temperature—about 60° F. (15·5° C.) in summer and 65° F. (18·3° C.) in winter—and a certain degree of exposure to the air. Extreme cleanliness must also be observed, the churn and other vessels employed being well scalded with hot water. When the butter is "come," it should be put into a fresh-scalded pan, or tub, which has been standing in cold water, cold water poured on it, and, after it has acquired some hardness, it should be well beaten with a flat board, until not the least taste of the butter-milk remains, and the water, which must be often changed, becomes quite colourless and tasteless. It may then be flavoured with a little salt.

It must be remembered that butter is not *pure* butter-fat, but consists of a mixture of water, curd, and salt, with from 78 to 90 per cent. of butter-fat. The water, curd, and salt may be separated by heating; the melted butter-fat soon rises, and may be removed from the underlying strata of curd and water. When so freed from impurities, butter-fat may be kept good for a considerable time, if air be excluded. It does not fall within the scope of this volume to treat fully of the analysis and adulteration of butter, occupying as this article does so important a place among foods. In several recent works on Food, &c., these subjects have been dealt with in a very exhaustive manner, and to these the reader who desires minute information on the subject is referred. It will be sufficient here to notice that the specific gravity of butter-fat, at the temperature of 100° F. (37·7° C.), varies from about 0·910 to 0·914, and, as first pointed out by Dr. JAMES BELL, since the specific gravities of the ordinary animal fats, at the same temperature, do not rise above 0·904, we have, in this difference, a ready means of determining the purity, or otherwise, of butter-fat. The melting point of the fat varies from 85° F. to 92° F. Methods for ascertaining the melting point of this and other fats, and for determining the proportions of the fatty acids, are described in a subsequent chapter.

Butterine.—*Syn.* BOSCH, OLEOMARGARINE, ARTIFICIAL

Butter.—The manufacture of artificial butter has of recent years assumed great dimensions, more especially in America and on the Continent. The following are the outlines of the process adopted in this industry in the United States:—

Beef suet, carefully picked so as to remove objectionable pieces, is thoroughly washed in warm and afterwards in cold water. Having been drained, and broken up into small fragments, it is placed in a melting pan, either steam jacketed or with a steam coil inside, and heated to a temperature not exceeding 120° F. (49° C.). The fat is afterwards drawn off, allowed to cool slowly, so as to permit the separation of stearin, down to the temperature of 70° F. (21° C.). At this temperature it is kept for twelve hours, or even longer, till a distinct granulation is noticed. The semi-solid fat is subjected to pressure between cloths; the solid portion, or stearin, is available for candle-making, and the liquid portion, consisting of olein and margarine, or oleomargarine, is collected for use in the manufacture of butterine. The oil so obtained is about half the quantity of the fat originally taken. It is too limpid for use in this state, and accordingly is mixed with milk, &c., in the proportion usually of 20 lb. oleomargarine, 8 pints of milk, 6 pints of water, and a small quantity of annatto, carbonate of soda, and salt. This mixture, at a temperature of 70° F. (21° C.), is run upon ice, so as to suddenly cool it. It is then ready for packing. Some of the oleomargarine is sent to other localities in America or to Europe, either to add to genuine butter or to make butterine. It is stated that about 6,000,000 lb. of the oil are annually exported from New York.

The specific gravity of oleomargarine at 100° F. (37·8° C.) has been found to vary from ·901 to about ·904, and its melting point from 78° F. to 82° F. Admixture with genuine butter is easily detected by the specific gravity test of

Dr. Bell, referred to under Butter-fat, and by determining the percentage of fixed and volatile acids, but, for the reason already mentioned under Butter, we do not here enter into details on this subject.

Lard and Lard Oil.—Lard is the fat of the pig melted by a gentle heat, and strained through flannel or a hair sieve. Good lard is white, and contains no water or other foreign matter, with the exception of a little salt when not intended for medical purposes.

According to Dr. J. Bell the specific gravity of lard at 100° F. varies from 0·90371 to 0·90483, the melting point from 108° to 114° F., the percentage of fixed acids from 95·62 to 95·93, and the percentage of moisture from 0·17 to 0·35.

Lard is said to be often adulterated—generally with water, but sometimes also, it is alleged, with starch, alum, lime, and carbonate of soda. The presence of water will be indicated by bubbles in the melted specimen, and its quantity can readily be determined by noting the loss of weight occurring on drying a known quantity in a water-oven. Lard free from all the other adulterants mentioned will be found quite clear when melted; if any sample appears opaque on heating, some foreign substance will probably be detected on further examination.

"Lard oil" is obtained when lard is subjected to great pressure in the cold. It consists chiefly of olein. It is said to be superior to olive oil for greasing wool, and, from its low price, is largely employed. Large quantities of this oil are made in the United States, the annual production being about 9,000,000 gallons.

Neat's-foot Oil.—*Syn.* Nerve oil, Trotter oil.—Prepared from the feet of oxen, which are obtained from the slaughter-houses. The feet are first soaked in cold water, to remove blood; then the sinews are removed, and the hoofs are boiled for two or three hours. A certain quantity of oil is then separated, but it is not of the best quality. The hoofs, after this oil has been taken off, are re-boiled in fresh water, and a further quantity of oil is then obtained. This is the first quality.

Some samples of the oil are colourless, but it is usually of a yellowish tint. Its specific gravity varies from about 0·915 to 0·9178 at 60° F. (15·5° C.). It does not congeal till cooled below 32° F. (0° C.), and, as it is not liable to rancidity, it is in great repute as a lubricant, more especially for machinery exposed to low temperatures. It is also used to soften leather and to clean fire-arms. Neat's-foot oil is very liable to adulteration, horse oil, lard oil, bone oil, and fish oils being often, it is said, employed for this purpose.

Tallow and Tallow Oil.—"Tallow" is the name given to the fat separated from the membranes enclosing it in the "suet" or solid fat as obtained from oxen, sheep, and other ruminants. The process by which this separation is accomplished is called "rendering," and is as follows:—

The suet is exposed, usually in an open copper, to a temperature high enough to liquefy the fat and tear asunder the cells containing it. To assist the operation the fat is divided into small pieces so as to allow the more uniform influence of the heat. The membranous matters collect at the top. These are removed and pressed so as to free them from oil. The solid matters—now called *greaves*, or *cracklings*, from their crispy nature—form flat cakes, and are sold as food for dogs, manure, or for use in the manufacture of ferrocyanide of potash. The melted fat is passed through a sieve into another copper, and washed with boiling water. The impurities settle down with the water, and the fat is drawn off into tubs and allowed to cool. Another plan is to keep the tallow melted for some time with about 2 per cent. of dilute sulphuric acid, employing constant agitation, and allowing the whole to cool slowly; then to re-melt the cake with a large quantity of hot water, and wash well. Another method is to blow steam through the melted fat. Some persons add a little nitre to the melted fat, and afterwards a little dilute nitric or sulphuric acid, or a solution of bisulphate of potash.

The quality of tallow varies according to the food of the cattle and other circumstances, and the superiority of Russian tallow is attributed to the fact that the food of the animals, for eight months of the year in that country, is dry fodder. There are several kinds of tallow met with in the market, the best being Russian, "beef," and "mutton." Inferior kinds are "town tallow," "melted stuff," and "rough stuff," which are chiefly utilized in soap-making.* There is not so great a demand as formerly for Russian tallow, which seems now being, to some extent, displaced by the article from America and New Zealand.

The best qualities are whitish in colour, but generally tallow has more or less of a yellowish tint. It should be practically free from water and mineral matters. Its melting point ranges from 115° F. to 121° F. If lower than this, the presence of a fat of a lower degree of hardness, such as "bone fat," may be suspected. It is often important to know the percentage of *free* acid in tallow. The method for ascertaining this will be found in Chapter IX.

Chemically, tallow consists chiefly of stearin, palmitin, and olein, the stearin predominating, but varying in proportion with the species of animal, and according to age and food. Hence mutton and deer tallow is mostly harder, and has a higher melting point than beef tallow.

If tallow is too dark coloured, it may be bleached either by exposure to light and air or by chemical reagents, as, for instance, by heating 100 parts of tallow with—

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* P.Y.C. is an abbreviation used in the tallow trade for *prime yellow candle*.

Sulphuric acid . .	1 part
Red chromate of potash .	½ „

or 200 parts of tallow may be treated with

Nitric acid .	1 part
Sulphuric acid .	1 „

In Germany, tallow treated with 2 per cent. of petroleum is free from duty. To free it from the resulting objectionable smell, place it in a cauldron, and for every 100 lb. add about ½ lb. zinc chloride dissolved in water; then pass steam through the mixture for two or three hours. Or, instead of steam, the mixture may be well boiled with a fourth of water for the same time.*

Tallow Oil.—This oil corresponds to tallow as lard oil to lard, and is obtained from tallow by pressure. The tallow is first melted, and the clear portion is drawn off, after the subsidence of impurities, into tubs fitted with perforated diaphragms covered with coarse flannel. As cooling proceeds, olein separates from the solid portions of the fat, the liquid oil is run off, pressure applied, and more oil obtained. It is very useful in the manufacture of the finer kinds of soap.

The following oils belonging to this division are of less importance:—

Name.	Preparation.	Properties.	Use.
Bone-fat or grease.	Fresh or refuse bones, bruised, boiled in water, and the fat skimmed off when cold.	Light yellow colour.	Soap-making.
Crocodile oil.	Prepared in Punjaub.	Solidifies at 33°F.	Leather dressing.

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* "Seifensied. Zeit." 39, 462; "J. Soc. Chem. Ind." 1884, 181.

Name.	Preparation.	Properties.	Use.
Egg oil.	1°. Heat yolks of eggs; treat dry residue with boiling alcohol; evaporate off spirit. 1 dozen eggs yield 1 oz. oil. 2°. Evaporate yolks of fresh eggs in silver vessel till oil exudes—then filter, with pressure, through ticking.	Bland; emollient; yellow colour; semifluid; commences to solidify at 46° to 50° F. (8° to 10° C.). Very sweet.	As ointment to sore nipples and excoriations; also to "kill" mercury.

(*b*) *Volatile Animal Oils.*

Bone Oil.—*Syn.* Animal oil, Dippel's oil, Oil of hartshorn, Oleum animale empyreumaticum, Oleum cornu cervi, Oleum dippellii.—This oil is obtained when bone-black, or animal charcoal, is made by the ignition of bones in iron cylinders. After rectification, it is known under the above names. The original Dippel's oil of pharmacy was produced by distillation from stags' horns, but all now met with in commerce is produced as above mentioned. It is fetid and dark coloured, and has a specific gravity of about 0·970. It is chiefly used to make lampblack. Prof. Anderson, of Glasgow, has found it to contain various nitrogenous basic bodies, among which are the following:—

Methylamine	CH_3H_2N
Ethylamine	$C_2H_5H_2N$
Propylamine	$C_3H_7H_2N$
Butylamine	$C_4H_9H_2N$
Amylamine	$C_5H_{11}H_2N$
Pyridine	C_5H_5N
Picoline	C_6H_7N

Lutidine	C_7H_9N
Collidine	$C_8H_{11}N$
Parvoline	$C_9H_{13}N$
Aniline	C_8H_9N
Pyrrol	C_4H_5N

Castoreum Oil.—Castoreum is a secretion of the beaver (*Castor fiber*). It is analogous to civet and musk. Castoreum contains a resin, fat, benzoic acid, salts, and a volatile oil. The oil can be separated by distilling the castoreum with water. Produce, 1 to 2 per cent.

Civet Oil.—Civet is a substance obtained from the civet cat (*Viverra civetta*), an animal somewhat resembling a fox, found in China and the East and West Indies. The civet is secreted in a sort of pouch between the anus and sexual organs. Several of these animals imported into Holland afford a considerable branch of commerce, especially at Amsterdam. The civet is squeezed out in summer every other day, in winter twice a week. Two scruples to one drachm, or more, are procured each time. It is frequently adulterated with spermaceti, butter, or a similar substance, but of a darker colour, obtained from the polecat. When pure, it has an odour intermediate between that of musk and ambergris, but less refined. Colour, pale yellow; taste, acrid; consistence, that of honey. M. BOUTRON-CHALARD states that civet contains free ammonia, stearin, olein, mucus, resin, a yellow colouring substance, salts, and a volatile oil. It is to this volatile oil that the odour of civet is due. It is the basis of the famous "Jockey Club" perfume.

B. FISH OILS.

Cod-liver Oil.—*Syn.* OLEUM JECORIS ASELLI, OLEUM MORRHUÆ.—The name of this oil sufficiently explains its source, but the methods of extracting the oil are various, differing in the localities of preparation, and also according to its purpose. Since 1841, when it was first introduced into this country as a remedy in phthisis by the late Dr. J. Hughes Bennett, of Edinburgh University, its careful preparation for medicinal use has been of great importance. It may be interesting here to quote Dr. Bennett's views regarding its use in such cases:—

1. Cod-liver oil is, as M. Taufflied pointed out, an *analeptic* (*ἀναλαμβάνω*, to repair), and is indicated in all cases of abnormal nutrition dependent on want of assimilation of fatty matter.

2. It is readily digestible under circumstances where no other kind of animal food can be taken in sufficient quantity to furnish the tissues with a proper amount of fatty material.

3. It operates by combining with the excess of albuminous constituents of the chyme, and forming in the villi and terminal lacteals those elementary molecules of which the chyle is originally composed.

4. Its effects in phthisis are to nourish the body, which increases in bulk and vigour; to check fresh exudations of tubercular matter; and to diminish the cough, expectoration, and perspiration.

5. The common dose for an adult is a tablespoonful three times a day, which may often be increased to four, or even six, with advantage. When the stomach is irritable, however, the dose to commence with should be a tea- or dessert-spoonful.

6. The *kind* of oil is of little importance therapeutically. The pure kinds are most agreeable to the palate; but the brown, coarser kinds have long been used with advantage, and may still be employed with confidence whenever cheapness is an object.

7. I have never observed its employment to induce

pneumonia or fatty disease of the liver or kidney, however long continued, although such complications of phthisis are also exceedingly frequent.*

The following are some of the methods of extracting this oil:—

(1°) *Medicinal.*—Large quantities are prepared in Newfoundland. The livers are carefully selected while quite fresh, washed, dried, and placed in barrels. The oil exudes by the pressure of the pieces on each other, and is ladled from the top. It is filtered through paper, and made up in tin cans or barrels. This oil is of straw colour, and has a slight fishy odour and taste. It is known as "natural medicinal."

(2°) *Medicinal.*—After the oil has been separated as above, the same livers are heated by water or steam, but the temperature is not allowed to exceed 180° F. (82° C.)—sometimes not above 112° F. (44·5° C.). The oil is skimmed off and filtered. Afterwards it is heated to expel water. It is kept in jars well secured from the air. This oil is darker than that obtained by the first process, some products being of a yellow colour, and others of a light brown.

(3°) *Tanners'.*—The livers remaining after the preceding operations are boiled, and a coarser, dark-brown oil is obtained, which is used by tanners and curriers.

Another process followed in Newfoundland may be described. It is as follows:—The fish when landed are handed over to a "fish-room keeper," whose duty it is to split and open the fish and to deposit the livers in small tubs holding 17 or 18 gallons each. The tubs are soon afterwards collected from the different "fish-rooms" and conveyed to the manufactory. The livers are here thrown into tubs filled with clean cold water, and, after being well washed and jerked over, are placed on galvanized-iron wire sieves to drain. They are next put into covered steam-jacket pans, and submitted to a gentle heat for about three-quarters of an hour, after which the steam is turned off, cold air again admitted, and the whole allowed to repose for a short time, during which the livers subside, and the oil separates and floats at the top. The oil is then skimmed off into tin vessels, and passed through flannel strainers into tubs, where it is left to settle for about twenty-four hours. From these the purer upper portion of the oil is run into a deep galvanized-iron cistern, and again left to clarify itself by defecation for a few days. It is now further refined by carefully passing it through clean, stout moleskin filters, under pressure. The transparent filtered oil is received into a clean galvanized-iron cistern, from which, by means of a pump, the casks are filled for exportation. The latter, before being filled, are seasoned and cleaned to prevent their imparting either flavour or colour to the pure oil. By this process the natural pale colour of the oil is maintained and its medicinal virtues preserved intact.

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* "Principles and Practice of Medicine." By Dr. J. HUGHES BENNETT.

The specific gravity at 60° F. of the pale oil varies from 0·9230 to 0·9238, of the light-brown from 0·9240 to 0·9245, and of the dark-brown from 0·929 to 0·9315.

As a *test of purity* that known as the sulphuric-acid test is often relied on. One drop of strong sulphuric acid added to 20 drops of the oil on a porcelain slab develops a violet colour, which passes into a yellowish or brownish red. This is really due to the presence of bile acids in the oil, and hence any liver oil will give the same reaction. It therefore merely serves to show that the oil comes from the liver and not from other parts of the animal. To detect the presence of combined iodine, upon which some have thought the therapeutic value of cod-liver oil depends, the sample is saponified by trituration with a little caustic potash and hot water, the resulting soap cautiously dried and incinerated, the ashes digested with water and filtered. The filtrate is then concentrated, and on addition of dilute sulphuric acid, starch paste, and chlorine-water the presence of iodine is indicated by the well-known blue coloration. The presence of iodine artificially added is best detected by agitating the oil with a little rectified spirit, and then testing this last for iodine. Or, a little solution of starch and a few drops of sulphuric acid may be at once added to the oil, when a blue colour will be developed if iodine or an iodide has been mixed with the sample.

Two tests for the presence of other fish oils have been proposed. M. Cailletet prepares a mixture containing

Solution of phosphoric acid of S.G.	1·44	.	12 parts
Sulphuric acid (con.) ,,	1·84	.	7 ,,
Nitric acid ,,	1·37	.	10 ,,

Then to 5 parts of the sample add 1 part of the mixture and 5 parts of petroleum spirit, and set aside for twenty-four hours. Then note the colour:—

Pure oil	Yellow
Ray-liver oil	Red
All other liver oils	Brown

M. Boudard's test is fuming nitric acid, which gives with pure oil a fine rose colour, but the development of this colour is interfered with by any admixture with other fish oils.

Menhaden, Straits, or Bank Oil is produced by subjecting to heat the *Alosa menhaden*, a kind of herring. After purification by boiling, filtration, and pressure, it is available for soap-making and tanning. It is sometimes used as a substitute for cod-liver oil, and sometimes mixed with linseed oil for painters' use.

It is remarkable from its forming a lime-soap, which, on distillation with excess of lime, yields the following volatile hydrocarbons :*—

		Boiling Point of the Fraction (Cent.).	Amount in the Crude Oil.
Amylene	C_5H_{10}	35° — 37°	0·8 per cent.
Quintane or Amyl hydride	C_5H_{12}	37° — 41°	
Hexylene	C_6H_{12}	65° — 66°	3·9 "
Hexane	C_6H_{14}	67·5°— 68°	2·8 "
Benzene	C_6H_6	80° — 81°	3·1 "
Heptylene	C_7H_{14}	93° — 94°	4·7 "
Heptane	C_7H_{16}	97·8°	7·6 "
Toluene	C_7H_8	110° —111°	6·9 "
Octylene	C_8H_{16}	121° —122°	12·5 "
Octane	C_8H_{18}	128° —129°	
Xylene	C_8H_{10}	140° —144°	13·3 "
Nonylene	C_9H_{18}	153°	7·8 "
Decylene	$C_{10}H_{20}$	165° —174°	23·5 "
Isocumene	C_9H_{12}		
Undecylene	$C_{11}H_{22}$	193° —196°	10·2 "
Duodecylene	$C_{12}H_{24}$	208° —213°	3·1 "

Seal Oil.—This oil is chiefly prepared from the blubber of the hooded seal (*Phoca cristata*) and of the harp seal (*Phoca greenlandica*), but also from several other species of seal.

Pale seal oil is that which drains from the blubber before putrefaction commences, and forms about 60 per cent. of the whole quantity of oil obtained. It is very clear, free from smell, and, when recently prepared, not unpleasant to the taste.

Refined seal oil is the last, washed and filtered. It ranks close after sperm oil.

Brown, or dark, seal oil is that which subsequently drains from the putrid mass. It is very strong-scented and nauseous, and smokes in burning.

A full-grown seal yields from 8 to 12 gallons of oil, a small one from 4 to 5 gallons.

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* WARREN A. STORER, "Mem. Amer. Acad." New Series, ix. 177; "Zeitschr. f. Chem." [2] iv. 228.

Shark, or Shark-liver, Oil.—Prepared from the liver of various species of shark. One liver yields from 15 to 60 gallons of oil. It is the lightest of the fixed oils, the specific gravity ranging from 0·865 to 0·876. Besides being employed in the adulteration of cod-liver oil, it is largely used in tanneries.

Sperm Oil.—This oil is procured from the "head-matter" of the sperm whale, or *cachalot* (*Physeter macrocephalus*), a species once common in all the principal seas, but now chiefly confined to the Southern oceans. It is a very limpid oil, comparatively free from smell, and burns well. It has long been reputed the best oil for lamps and machinery, as it does not thicken by age or friction. Its specific gravity is 0·875. Refined seal oil is a common adulterant.

The solid portion is refined for the purpose of candle-making, the product being a tasteless, inodorous, colourless solid, of specific gravity 0·943.

Whale Oil.—The source of this oil is the common or Greenland whale (*Balæna mysticetus*). The whale-fishing vessels merely collect the blubber and carry it packed in casks to the seaports to be melted down. During the voyage a decomposition of animal matters takes place, which, though it assists in the extraction of the oil, occasions a very unpleasant odour. The blubber is put into casks with wire-work bottoms, and the oil allowed to drain away. It is afterwards heated so that impurities may be separated, allowed to stand, and the clear oil decanted off. Its colour is brownish, and its specific gravity 0·923. It is sometimes called *train oil*, but under this term are also included oils from seal, cod, shark, and other fish of a like nature. Stinking train oil may be purified by passing steam through it, and it will afterwards remain sweet for several months.

The following are some other oils belonging to this division of less importance:—

Name.	Source.	Use.
Houlican or Oolachan oil.	A kind of smelt (*Thaleichthys pacificus*), by warming over a slow fire.	As cod-liver oil in British Columbia and Vancouver's Island.
Malabar oil.	Livers of *Rhyncobutus pectinata*, &c.	Medicine: lighting; soap-making.
Manatee oil.	Several species of *Manatus*.	Lighting; cooking.
Porpoise oil.	Black porpoise (*Phocœna communis*). White whale (*Phocœna leuca*). Grampus (*Phocœna orca*).	Lighting; lubricating; leather-dressing.
Sod oil.	Washed out of skins with soda, after fulling with olive, cod, or menhaden oil.	Lubricating watches.

Fish Oils (*Volatile*).

Ambergris.—*Syn.* Grey amber, Ambragrisea.—This is an odorous solid substance found floating on the sea in tropical climates, and in the cæcum of the cachalot or spermaceti whale (*Physeter macrocephalus*). It has been supposed by some to be a morbid secretion of the liver, or intestines, analogous to biliary calculi; but, according to Mr. Beale, it consists of the mere indurated fæces of the animal, perhaps (as suggested by Brande and Pereira) somewhat altered by disease. "Some of the semi-fluid fæces, dried with proper precautions, had all the properties of ambergris" (Beale). It is occasionally found in masses weighing from 60 to 225 lb.

Ambergris is an opaque, ash-coloured, streaked, or variegated solid, with a pleasant musk-like odour, which is heightened by warming, the odour being peculiar and not easily described or *imitated*, of a very diffusive and penetrating character, and perceptible in minute quantities. It does not effervesce with acids. Melts at 140°–150° F. to a yellowish resin-like mass; at 212° F. it flies off as a white vapour. Very soluble in alcohol, ether, and the volatile and fixed oils. It appears to be a non-saponifiable fat analogous to cholesterine. Specific gravity, 0·78 to 0·926.

From the high price of genuine ambergris, it is very frequently adulterated. When quite pure and of the best quality it is—1° Nearly wholly soluble in hot alcohol and ether, and it yields about 85 per cent. of *ambreine*, which is deposited, as the alcoholic solution cools, in an irregular crystalline mass. 2° It almost entirely volatilizes at a moderate heat, and, when burnt, leaves no notable quantity of ash. A little of it exposed to heat in a silver spoon melts without bubble or scum. 3° It is easily punctured with a heated needle, and on withdrawing it, not only should the odour be immediately evolved, but the needle should come out clean, without anything adhering to it (NORMANDY). 4° The Chinese are said to try its genuineness by scraping it fine upon the top of boiling tea. It should melt, and diffuse on the surface. 5° Its surface should be rugged—the smooth and uniform is generally factitious.

Mixed with other perfumes, it is found greatly to improve and exalt their odours: hence its extensive use in perfumery. In *medicine* it was formerly given as an aphrodisiac, in doses of 3 to 10 grains. A grain or two, when rubbed down with sugar and added to a hogshead of claret, is very perceptible in the wine, and gives it a flavour, by some considered as an improvement (BRANDE).

A factitious ambergris is said to be thus made:—

Orris powder	1 lb.
Spermaceti	1 lb.
Gum benzoin	1 lb.
Asphaltum	3–4 oz.

Ambergris	6 oz.
Grain musk	3 dr.
Oil of cloves	1 dr.
Oil of rhodium	½ dr.
Liquor ammoniæ	1 fl. oz.

Beat to a smooth hard mass with mucilage, and make into lumps whilst soft. This fraud is easily detected.

C. INSECT OILS.

Ant Grease is obtained by boiling white ants in water, and skimming off the fat as it rises. It is used as food.

Cochineal Fat, from the well-known cochineal insect (*Coccus cacti*).

Niin Oil.—This interesting oil is very fully described in Spon's "Encyclopædia": "It is extracted from the insects, a species of *Coccus,* by broiling or boiling them, and amounts to 26–28 per cent. of their weight. It is bright yellow to yellowish-brown in colour, and possesses a peculiar odour. Melts at 120° F. (49° C.). At ordinary temperatures it is thick and pasty, like lard, and its specific gravity is about 0·920. It is a thorough drying oil, though its absorption of oxygen is slow, and this is not hastened by oxide of lead. The present native uses of this remarkable oil, which has yet to find its way into general commerce, are almost confined to admixture with pigments employed by the Indians in Yucatan and in the vicinity of Vera Cruz for adorning small household articles. In the industrial arts its drying solution in turpentine will make it valuable to artists; it remarkably brightens colours prepared with it. The turpentine solution of niin oil renders even the most porous filter-paper absolutely impervious to water. Articles to be waterproofed with it might be saturated in the solution and then heated in an oven till the grease volatilizes. The coating then defies most solvents of oils."

CHAPTER III.

VEGETABLE OILS.

(a) fixed; (b) volatile.

(a) FIXED VEGETABLE OILS.

THE fixed oils, except where otherwise directed, are obtained from the bruised or ground fruit or seed, by means of powerful pressure, in screw or hydraulic presses, and are then either allowed to clarify themselves by subsidence or are filtered. Both methods are frequently applied to the same oil. In some cases the impurities are removed by ebullition with water, and subsequent separation of the pure oil. Heat is frequently employed to increase the liquidity of the oil, and thus lessen the difficulty of its expulsion from the mass. With this object the bruised mass, placed in bags, is commonly exposed to the heat of steam, and then pressed between heated plates of metal. This is always necessary with the "butyraceous oils."

Another method is by boiling the bruised seed in water, and skimming off the oil as it rises to the surface. This is the plan adopted for castor oil in the West Indies.

In a few cases, for medicinal purposes, the bruised mass is mixed with half its weight, or an equal weight, of alcohol or ether, and after twenty-four hours' digestion the whole is submitted to pressure, and the alcohol or ether removed by distillation at a gentle heat. The first menstruum is com-

**mployed for croton oil on the Continent; the second,
of ergot of rye.**

**s been already stated (p. 10) that certain oils
with nitrous acid afford a solid substance called
and that certain other oils are unaffected when so
The former are called "non-drying oils," the
drying oils." The fixed vegetable oils may be con-
ly studied under these two heads. The following
en from WATTS' "Dictionary of Chemistry," includes
e important of these oils :—**

Drying Oils.

ame.	Plant from which derived.	Specific Gravity.	Solidifying Point (Cent.).
or	*Ricinus communis*	0·963	– 18°
s-seed ...	*Lepidium sativum*	0·924	– 15°
on-seed...	*Gossypium barbadense*	0·9306	
lly night-iade	*Atropa belladonna*	0·925	– 27·5°
of plea-ire	*Camelina sativa*	0·9307	– 19°
d-seed ...	*Cucurbita pepo*	0·9231	– 15°
e-seed ...	*Vitis vinifera*	0·9202	– 11°
p-seed ...	*Cannabis sativa*	0·9307	– 27·5°
sty	*Hesperis matronalis*	0·9232	Below – 15°
ed	*Linum usitatissimum*	0·9351	" – 20°
i	*Madia sativa*	0·9286	" – 10°
y	*Papaver somniferum*	0·9270	– 18°
ower ...	*Helianthus annuus*	0·9250	– 16°
h-fir seed	*Pinus sylvestris*	0·9312	– 30°
r-fir cones	*Abies picea*	0·926	
ce fir ...	*Abies excelsa*	0·9283	Below – 15°
cco-seed	*Nicotiana tabacum*	0·9232	– 15°
nut, or nut	*Juglans regia*	0·9287	– 18°
l-seed ...	*Reseda luteola*	0·9358	Below – 15°

–The principal vegetable drying oils are linseed, poppy-seed,
d, and nut oils. Castor and cotton-seed oils seem to be inter-
etween drying and non-drying oils, and are sometimes classed
e latter.

Non-drying Oils.

Name.	Plant from which derived.	Specific Gravity.	Solidifying Point (Cent.).
1. Almond.........	*Amygdalus communis*	0·9184	− 21°
2. Beech-nut......	*Fagus sylvatica*	0·923	− 17·5°
3. Colza............	*Brassica campestris oleifera*	0·9136	− 6°
4. Croton	*Croton tiglium*	0·94263	
5. Cyperus-grass.	*Cyperus esculentus* (*root*)	0·918	
6. Daphne.........	*Daphne mezereum*	0·914–0·921	
7. Earth-nut......	*Arachis hypogæa*	0·918	
8. Ergot............	*Secale cornutum*	0·922	− 37°
9. Hazel nut......	*Corylus avellana*	0·91987	− 19°
10. Henbane-seed	*Hyoscyamus niger*	0·913	
11. Horse-chestnut	*Œsculus hippocastanum*	0·915	+ 8°
12. Black mustard	*Sinapis nigra*	0·92102	Below 0°
13. White ,,	,, *alba*	0·93383	Does not solidify
14. Olive	*Olea europæa*	0·916	
15. Palm	*Elæis guineensis*	0·968	
16. Palm-nut	,, ,,		
17. Parsley	*Petroselinum sativum*	1·078 at 12° C.	Turbid at 12° but does not solidify
18. Plum-kernel ...	*Prunus domestica*	0·9127	− 8·7°
19. Rape-seed (summer)...	*Brassica præcox*	0·91555	
20. Rape-seed (winter) ...	,, *napus*	0·91648	Below 0°
21. Sesamé	*Sesamum orientale*	0·92415	− 5°
22. Spindle-tree ...	*Euonymus europæus*	0·95717	− 12° to − 15°
23. Spurge	*Euphorbia lathyris*	0·92613	− 11¼°

NOTE.—The most important non-drying oils are almond, colza, rape-seed, olive, and palm oils.

Drying Oils.

Belladonna Oil.—*Syn.* OLEUM BELLADONNÆ SEMINUM, O. B. BACCÆ, L.—From the seeds or berries of *Atropa belladonna,* or deadly nightshade. It is of a yellow colour and insipid taste. It is used for lamps in Swabia and Würtemberg, and as an application for bruises. The marc is poisonous. Freezes at 34° F. Specific gravity, 0·9250.

Castor Oil.—*Syn.* Ricini oleum (B. P.), Oleum castorei, O. ricini (Ph. L., E., and D.).—"The oil prepared by heat or by pressure, from the seed of *Ricinus communis*, Linn." (Ph. L.), the *Palma christi*, or Mexican oil-bush.

Cold-drawn castor oil (Oleum ricini sine igne) is the best quality, and the only one fit for medicinal use, except in veterinary practice. It is prepared by pressing the shelled and crushed fruit, or seed, in hempen bags in hydraulic presses. The oil, as it escapes, is received into well-tinned vessels, in which it is afterwards mixed with water and heated till the water boils, and the albumen and gum separate as a scum. This is carefully removed, and the oil, as soon as it has become cold, is filtered through Canton flannel and put into canisters. It is termed "cold drawn," and is of a light straw colour.

Commoner kinds of oil are prepared by gently heating the crushed seeds, and pressing them while hot. Another method sometimes adopted is to put the crushed seed into loose bags, to boil these in water, and to skim off the floating oil. The oils prepared by combined roasting and boiling are darker in colour than when "cold drawn;" they are also more viscid, and soon become rancid. They are used for lamps in Indian bazaars.

In the United States a somewhat different method of extraction is adopted. The cleansed seeds are heated in an iron tank, with care to avoid scorching. Pressure is then applied, and "1st quality" oil is drawn off. The pressed residue is again heated and squeezed, the product being "2nd quality" oil. A "3rd quality" oil is obtained after a repetition of the heating and pressure. Each of these three products has to be further purified by heating with water, as described above under "cold-drawn" oil.

It is the most viscid of all the fixed oils. When pure, it mixes in all proportions with alcohol and ether, and also dissolves, to a certain extent, in rectified spirit, but a portion of the oil separates on standing. Camphor and benzoic acid increase its solubility in spirit. By long exposure to the air it becomes rancid and thick, and is ultimately transformed into a transparent, yellow mass; light hastens these changes. Exposed to cold, a solid, white, crystalline fat separates from the liquid portion, and when cooled to 0° F. (– 18° C.) it congeals to a yellow, transparent mass, like varnish, which does not again liquefy until the temperature rises to about 18° F. Sp. gr. 0·9611 to 0·9612 at 60° F., 0·9690 at 55° F. (Saussure), 0·9575 at 77° F. (Saussure). Produce, 38 to 40 per cent.

Castor oil is sometimes adulterated with rape oil or lard oil, a fraud which may be detected by its diminished density, and, when the added oil exceeds 33 per cent., by its insolubility in its own weight of alcohol of 0·820. In some cases, it is said, croton oil is added to increase the purgative quality of the mixture. A compound of this kind has been vended in gelatine capsules under the name of "concentrated castor oil," the use of which is fraught with danger. Pereira says, "I have heard of several cases in which very violent and dangerous effects were produced by these capsules."

The best castor oil is imported from the East Indies in tin canisters. The oil obtained from the seeds of *Ricinus viridis* (Willd.), or lamp-oil seeds, is often mixed with, or sold for, castor oil.

In medicine, castor oil is exceedingly useful as a mild purgative, particularly when abdominal irritation should be avoided, as in inflammation of the stomach and bowels, pregnancy, surgical operations, &c. *Dose*, 2 fl. dr. to 1 fl. oz.

Italian castor oil is said to have a less nauseous taste than the Indian or American oils, and this has been ascribed* to the fact that it is prepared from fresh seeds, well decorticated, and often not bruised, and to its extraction without heat.

Castor oil rotates a ray of polarized light. 10 per cent. solutions of pure Italian and Ostend castor oil in absolute alcohol gave, as a mean result, a direct deviation of 10° to the right, which gives as the specific rotatory power of castor oil $(a) = +12{\cdot}15^\circ$. This behaviour may be used as a test of its purity, although the rotation is too small to allow a slight adulteration to be detected. Castor oil also contains a small quantity of nitrogen, which may be due to the presence of an alkaloid. It is possible, indeed, that not only the purgative properties, but also the circular polarization, are due, not to the oil itself, but to the presence of this alkaloid.†

Cotton-seed Oil.—*Syn.* OLEUM GOSSYPII SEMINUM.—Prepared from the seeds separated from the "lint" or "wool" of *Gossypium barbadense.* The cleaned and decorticated seeds are pressed into cakes, which are subjected to heat and again pressed so as to liberate the oil. The yield is from 12 to 20 per cent. The specific gravity of the crude oil, according to W. GILMOUR, varies from 0·928 to 0·930, and of the refined oil from 0·920 to 0·923, and the congealing point from 45° F. to 32° F. The refined oil has a yellowish-brown colour and a somewhat pleasant flavour. It possesses slight drying properties, but is sometimes classed among non-drying oils. It is used for paints, lamps, and in soap-making. It has also a limited use for lubricating purposes.. It is largely used as an adulterant of other oils, especially of olive, linseed, sperm, and lard oils.

Cotton-seed oil treated with oil of vitriol gives a violet colour, increased by stirring. With caustic alkalies (sp. gr.

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* "Pharm. Jour." [2] vi. 230.

† POPP. "Arch. Pharm." [2] cxlv. 233; WATTS' "Dictionary of Chemistry," 2nd Suppt. 270.

1·24) the oil thickens, becomes straw-coloured, while the alkaline solution separates and takes a deeper colour. If the mixture is stirred with a glass rod, the upper layers become bluish-coloured and gradually violet.

Cress-seed Oil.—Obtained from the seeds of *Lepidium sativum*. It has a brownish-yellow colour, and a specific gravity of about 0·924. On cooling to 21° F. (— 6° C.) it becomes thick, and solidifies at 5° F. (— 15° C.). It dries slowly.

Dilo Oil.—*Syn.* TAMANU OIL.—Procured from the seeds of *Calophyllum inophyllum*, a large tree growing in India, Ceylon, and other tropical countries. The seeds, after exposure for some weeks to the heat of the sun, are separated from the shells, crushed or ground, and pressed. The yield varies in different localities, through differences of treatment, from 30 to 80 per cent. Colour greenish; specific gravity about 0·940. It is suitable for soap-making, and for paints. It dries rapidly.

Gold of Pleasure Oil.—Extracted from the seeds of *Camelina sativa* by pressure. It has a specific gravity of 0·925. It is of a clear golden colour, and mild taste. It solidifies about −2° F. (18·9° C.). It dries rapidly. Its chief uses are for lamps, dressing woollen goods, and in paints.

Grape-seed Oil.—*Syn.* WINE-SEED OIL, GRAPE-STONE OIL, OLEUM VITIS VINIFERÆ LAPIDUM.—The seeds are separated from the marc, cleaned, dried, and finely ground. Subsequently both cold and hot pressure are employed, and a yield of from 14 to 18 per cent. obtained. The fresh oil is of a pale-yellow colour, but darkens with age. Its sp. gr. is from 0·918 to 0·920. It has a low congealing point—about 5° F. (– 15° C.)—and hence has been sometimes used for lubricating, but it is mostly employed for salads and lamps.

Hemp-seed Oil.—*Syn.* HEMP OIL, OLEUM CANNABIS.—Obtained from the seeds of *Cannabis sativa*, or common hemp. It has a mild odour, mawkish, unpleasant taste, and a greenish yellow colour, turning brown with age. In sp. gr. it varies from 0·925 to 0·931. It does not thicken till cooled to 5° F. (– 15° C.). It is freely soluble in boiling alcohol. It is sometimes used for frying, but chiefly for paints and soft-soaps. The seeds yield from 18 to 30 per cent. of oil.

Linseed Oil.—*Syn.* OLEUM LINI.—Commercially, this oil is obtained from the seeds of *Linum usitatissimum* as imported from Russia and India, which contain varying proportions of different cruciferous weed-seeds. The oil has usually, therefore, an acrid taste, derived from the presence of these impurities. There are three kinds of the oil, according to the method of preparation:—

(1°) *Cold drawn.*—*Syn.* OLEUM LINI SINE IGNE.—The seeds are bruised or crushed, ground, and expressed without heat. This is considered the best oil. It is pale, tasteless if pure, viscous, but does not keep so well as the next. By this process the seeds yield only from 17 to 22 per cent. of oil.

(2°) *Ordinary linseed oil.*—Prepared as the last, but with a steam heat of about 200° F. It is amber-coloured or dark yellow, and is less viscous than the last. It solidifies about 2°–4° F. (– 18·9° to – 20° C.). It is soluble in 5 parts of boiling and 40 parts of cold alcohol. Produce, 22 to 28 per cent.

Both these are drying and cathartic, and are extensively used in paints, printing inks, varnishes, &c. In sp. gr. they vary from 0·930 to 0·935.

Linseed oil is also largely used in the manufacture of floorcloths, "Baltic" being the most suitable for this purpose. The best way to test the oils before use is the following[*]:—Boil about 2 gallons in an iron pot with the addition of ½ per cent. of ground litharge and ½ per cent. of red lead. The temperature should not rise above 260° C. (500° F.). In order to accelerate the process of oxidation, air is blown into the hot oil by means of a pair of ordinary bellows. Samples are taken from time to time and cooled upon an iron plate. As soon as it appears stringy when cool, the pot is removed from the fire, and its contents are stirred till cold. If it is then solid, it is suitable: bad oil remains sticky and semi-liquid. The time occupied by the above test is from two to four hours. Frothing over the edge of the pot may be prevented by continually raising some of the oil in a ladle and letting it fall back again into the pot.

(3°) *Boiled linseed oil.*—The resinifying or drying property of oils is greatly increased by boiling them, either alone or along with some litharge, sugar of lead,[†] or white vitriol, when the product forms the "boiled oil" or "drying oil" (Oleum desiccativum) of commerce. The efficacy of the process, according to Liebig, depends on the elimination of substances which impede the oxidation of the oil. The following formulæ are adopted for this purpose:—

(1) Linseed oil, 1 gall.; powdered litharge, ¾ lb.; simmer,

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[*] Spon's "Encyclopædia," iii. 1002.

[†] Driers.—Driers are substances employed to facilitate the drying of paints. The driers most commonly employed are sugar of lead, litharge, and white copperas. Either of these when well ground, and mixed in small proportion with paints, very materially hastens their drying. Indeed, some colours will not dry without them. Red lead is also well adapted for a drying agent, and, in cases where its colour does not preclude it, is much used. The best drier is sugar of lead. Its cost, however, is somewhat higher than that of the other driers. It is important to bear in mind that in the finishing coats of delicate colours driers are not generally had recourse to, as they have a slight tendency to injure the colour.

with frequent stirring, until a pellicle begins to form; remove the scum, and, when it has become cold and has settled, decant the clear portion. Dark coloured; used by house-painters.

(2) Linseed oil and water, of each 1 quart; white vitriol, in powder, 2 oz.; boil to dryness. Paler than the last.

(3) Pale linseed or nut oil, 1 pint; litharge or dry sulphate of lead, in fine powder, 2 oz.; mix, agitate frequently for ten days, then set the bottle in the sun or a warm place to settle, and decant the clear portion. Very pale.

(4) Linseed oil, 100 galls.; calcined white vitriol ("sulphate of zinc"), in fine powder, 7 lb.: mix in a clean copper boiler, heat the whole to 285° F., and keep it at that temperature, with constant stirring, for at least one hour; then allow it to cool, in twenty-four hours decant the clear portion, and, in three or four weeks more, rack it for use. Used for varnishes.

(5) (LIEBIG.) Sugar of lead, 1 lb., is dissolved in rain water, ½ gall.; litharge, in fine powder, 1 lb., is then added, and the mixture is gently simmered until only a whitish sediment remains; levigated litharge, 1 lb., is next diffused through linseed oil, 2½ galls., and the mixture is gradually added to the lead solution, previously diluted with an equal bulk of water; the whole is now stirred together for some hours, with heat, and is, lastly, left to clear itself by exposure in a warm place. The lead solution which subsides from the oil may be used again for the same purpose by dissolving in it another lb. of litharge, as before.

(6) (WILKS.) Into linseed oil, 236 galls., pour oil of vitriol, 6 or 7 lb., and stir the two together for three hours; then add a mixture of fuller's earth, 6 lb., and hot lime, 14 lb., and again stir for three hours; next put the whole into a copper, with an equal quantity of water, and boil for about

three hours; lastly, withdraw the fire, and when the whole is cold, draw off the water, run the oil into any suitable vessel, and let it stand for a few weeks before using it. (*Patent.*)

(7) ("Allg. Polytech. Zeitung.") Binoxide of manganese (in coarse powder, but not dusty), 1 part; nut or linseed oil, 10 parts; mix, and keep the whole gently heated and frequently stirred for twenty-four to thirty-six hours, or until the oil begins to turn reddish. Recommended for zinc paint, but is equally adapted for other purposes for which boiled oil is employed.

There is often a difficulty in obtaining the oils "bright" after boiling or heating them with the lead solutions; the best way, on the small scale, is either to filter them through coarse woollen filtering paper, or to expose the bottle for some time to the sun or in a warm place. On the large scale, the finer oils of this kind are often filtered through Canton-flannel bags. The litharge and sulphate of lead used in the above processes may be again rendered available for the same purpose by washing them in hot water, to remove adhering mucilage.

The specific gravity of boiled linseed of good quality varies from 0·940 to 0·950, and on ignition it leaves a mineral residue of from 0·2 to 0·4 per cent.

Poppy-seed Oil.—*Syn.* OLEUM PAPAVERIS.—Obtained from the seeds of *Papaver somniferum*, the opium poppy, *Glaucium luteum*, the yellow-horn poppy, and *Argemone mexicana*, the spiny poppy, by pressure. It is of a pale colour, and slightly sweet taste. It dries and keeps well, and has a specific gravity of 0·913–0·924. It is used for salads, paints, and soaps, and also extensively to adulterate almond oil. It does not freeze till cooled to 0° F. The yield of the seeds is from 32 to 48 per cent.

Sunflower Oil.—*Syn.* OLEUM HELIANTHI.—Prepared from seeds of *Helianthus annuus* and *Helianthus perennis*. It is clear, tasteless, and of a pale yellow colour. It dries slowly, thickens and becomes turbid at 60° F. (15·5° C.), and solidifies at 4° F. (– 16° C.). Its specific gravity is 0·926. Messrs. MILLS and MUTER found its bromine absorption 51·45. It is used for salads and for lamps, and also for adulterating olive oil. The seeds yield from 15 to 28 per cent. of oil.

Tobacco-seed Oil.—*Syn.* OLEUM TABACI EXPRESSUM.—From the seeds of *Nicotiana tabacum* and other species of *Nicotiana*. The seeds are ground to a powder, made into a paste with water, and pressed hot. The oil is of a pale-yellow colour, and dries well, being considered by some equal in this respect to nut oil. Its production has recently been carried on with success in Russia. Its specific gravity is 0·923.

Walnut Oil.—*Syn.* OLEUM JUGLANDIS, OLEUM NUCIS, NUT OIL.—The kernels of the nuts of *Juglans regia*, or common walnut tree, are separated from the shells and skins, crushed, and pressed. After the "cold-drawn" or "virgin" oil has been obtained, the residue is pressed, with the aid of heat, and a further quantity of oil, called "fine-drawn," is procured. The former, when well washed, is of a pale colour and has a slight smell. It is sometimes used as a salad oil. Its specific gravity is about 0·926 at common temperatures, and it solidifies at about – 17½° F. (– 27½° C.). The latter dries well, but soon gets rancid. As a drying oil, many prefer it to linseed. The kernels yield from 48 to 52 per cent. of oil.

Non-drying Oils.

Almond Oil.—*Syn.* OLEUM AMYGDALÆ, OL. AMYGDALARUM, O. AMYGDALI COM.—There is both a fixed and a volatile oil obtained from almonds. The latter will be found described on p. 80. The following remarks apply only to the fixed oil. The medicinal (B. P.) oil, and also that of commerce, are obtained by pressure both from sweet and bitter almonds, but mostly from the latter, because it is cheaper, and because of the value of the residual cake, which is available for the preparation of the essential oil. It is odourless, and has a yellow colour. It is to the palate one of the most agreeable of the fixed oils. Its specific gravity varies from 0·915 to 0·920 at 60° F. (15·5° C.). It chiefly consists of olein (triolein) and hence requires great cold to solidify it (– 25° C.), being less affected by cold than olive oil. It is soluble in 25 parts of cold and 6 of boiling alcohol, and mixes in all proportions with ether. It is used as a medicine, and is bland, demulcent, and emollient. It is considered nutritious, though difficult of digestion. The following are the alleged adulterants of this oil :—lard oil, nut oil, olive, teel (sesamé or gingelly oil), poppy, rape or colza, and castor oils. Also mustard and peach-kernel oils (SPON). Produce obtainable from sweet almonds, 46 per cent.; from bitter almonds, 41 per cent.

The presence of teel oil, when it amounts to about 10 per cent., may be detected in almond oil by the following test: * "The oil shaken with a mixture of equal weights of sulphuric and nitric acids previously cooled takes a fine green hue, as shown in 1852 by BEHRENS, who at the same time pointed out that no other oil exhibits this reaction." MABEN in 1883 pointed out that this green quickly changes to brown.

Castor oil † may be detected by shaking with ammonia. Pure almond oil gives a perfect emulsion, whereas, in the presence of 5 per cent. of castor oil, drops of oil separate at the bottom, the quantity increasing with the percentage of the adulterant.

ALLEN has suggested ‡ that the presence of mustard oil

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* "Pharmacographia."

† "Chemist and Druggist," May 1883.

‡ "Commercial Organic Analysis," ii. 182.

might be detected by boiling the sample with an equal measure of a 10 per cent. solution of caustic soda, filtering through a wet filter, and testing the filtrate with lead acetate, when a dark coloration would indicate the probable presence of mustard oil, as the oils from cruciferous seeds contain traces of sulphur compounds.

The presence or absence of these and the other adulterants mentioned may also be indicated in the course of the examination laid down in CHATEAU'S tables (see Chap. IX.).

Bay Oil.—*Syn.* LAUREL OIL.—1° (EXPRESSED OIL OF BAY, OLEUM LAURI, O. LAURINUM, L.).—By expression from either fresh or dried bay-berries. It is limpid and insipid.

2° *By decoction* (BUTTER OF BAY, OLEUM LAURI NOBILIS, O. LAURINUM VERUM, L.)—From the berries by boiling them in water and skimming off the oil. It is of a greenish colour, and buttery consistence. It is chiefly imported from Italy, and is a popular remedy for bruises, sprains, rheumatism and deafness. It is also used by veterinary surgeons. A volatile bay or laurel oil is also known (see p. 84).

Beech Oil.—*Syn.* OLEUM FAGI.—Extracted by cold or hot expression of the decorticated nuts of the beech tree (*Fagus sylvatica*). It is a clear oil, of a yellow colour, and, when fresh, has a slightly acrid taste, which, however, diminishes by keeping, or by ebullition with water. It keeps well, and, after washing with hot water, is used for salads in France, for burning in lamps, and for making soap. Its specific gravity is 0·9225 at 60° F. (15·5° C.). The nuts yield, on an average, 16 per cent. of oil.

Ben Oil.—*Syn.* BEHEN OIL, OLEUM BALATINUM.—Obtained by simple expression from the seeds of various species of *Moringa*, trees resembling willows, indigenous to Arabia and Syria, but grown also in the West Indies. The oil is colourless and odourless, and possesses an agreeable flavour. By cooling, the more solid portions separate and the parts remaining fluid, which are not apt to turn rancid, are much used for lubricating clocks and watches. Owing to the power of the oil for retaining odours, it is highly valued by perfumers, and is used in the preparation of macassar oil. It is also used in medicine, and sometimes as a salad oil. Its specific gravity varies from 0·912 to 0·915 at 60° F. (15·5° C.). It is said to be occasionally adulterated with olive oil.

Benne-seed Oil.—*See* GINGELLY OIL.

Brazil-nut Oil.—*Syn.* OLEUM BERTHOLLETIÆ.—From the kernels of the fruit of *Bertholletia excelsa*, or Brazil nuts. It is of a bright amber colour, congealing at 24° F. Specific gravity, 0·917. It has been used as a substitute for olive oil in plasters and ointments.

Cacao Oil or Butter.—*Syn.* BUTTER OF CACAO, OLEUM CACAO CONCRETUM, BUTYRUM CACAO, OLEUM THEOBROMATIS.—From the seeds or nibs of *Theobroma cacao*, or chocolate nuts, gently heated over a fire, then decorticated, and pressed between hot iron plates. The nibs are capable of yielding about 50 per cent. of fat. When pure, it is white, and has a pleasant odour and taste. It does not readily become rancid. It is soluble in boiling alcohol, from which it crystallizes on cooling. It fuses at about 86° F. (30° C.). Its specific gravity varies from 0·945 to 0·952. It is used in pharmacy as a basis for suppositories and pessaries.

Cocoa-nut Oil.—*Syn.* COCOA-NUT BUTTER, OLEUM COCOIS NUCIFERÆ, L.—A species of vegetable butter obtained from the common cocoa-nut (*Cocos nucifera*) or cocoa palm. It is separated from the dried kernels by hydraulic pressure. It contains olein and a solid fat often used as a candle material. Large plantations of the cocoa palm connected with Price's Candle Company exist in Ceylon. Cocoa-nut oil is frequently confounded with cocoa or cacao-butter, which is the produce of a very different plant, the *Theobroma cacao*. The dried pulp of the cocoa-nut is called "copra" or "copperah," and hence the oil is sometimes called copra oil. As imported, the oil is of the consistence of butter, but has a lower melting point, fusing at about 73° to 80° F. (22·7° to 26·6° C.). When fresh, it has the sweet taste and agreeable odour of the cocoa-nut, but has a great tendency to become rancid. Its specific gravity closely approximates to that of pure butter-fat, and if its flavour could be masked so as to admit of its use for adulterating butter, the specific-gravity test would not indicate the sophistication. The adulteration, however, would be detected, according to Dr. J. BELL,[*] by the abnormally low melting point, and the diminished percentage of soluble fatty acids, when calculated as butyric acid. It is largely employed in the manufacture of candles and soap.

Croton Oil.—*Syn.* CROTONIS OLEUM (B. P.), OLEUM CROTONIS (Ph. E.), OLEUM TIGLII (Ph. L.).—This valuable oil is procured from the shelled seeds of *Croton tiglium,* or Molucca grains. It is imported chiefly from the East Indies. The oil is extracted from the ground seeds by pressure in bags between iron plates. It is allowed to stand for some days before being filtered. In France the marc is afterwards extracted with alcohol, and the oil thus obtained is added to the quantity previously expressed from the same seeds. The East Indian oil (OLEUM CROTONIS EXOTICUM) is usually of a pale colour; that pressed in England (O. CROTONIS ANGLICANUM) is much darker. It has an acrid flavour, and slight odour. In specific gravity it varies from about 0·942 to 0·953. WARINGTON[†] states that *fresh* croton oil, or oil expressed from *fresh* seeds, does not dissolve in alcohol of sp. gr. 0·794–0·796 to a greater extent than 20 per cent. at a temperature of 50° F., but if the oil be old or resinous, it is freely soluble. Hence this is not reliable as a test for purity.

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[*] "Analysis and Adulteration of Foods," Pt. II. 72.

[†] "Pharm. Journ." [2], vi. 384, 385.

It is one of the most powerful cathartics known, and acts either when swallowed or merely placed in the mouth. Externally it is a rubefacient and counter-irritant, often, like tartar emetic, causing a crop of painful pustules. *Dose*, 1 to 2 drops, on sugar; in apoplexy, &c. The unshelled seeds yield 22 to 25 per cent. of oil; the shelled seeds from 32 to 35 per cent.

SENIER has shown* that the part of croton oil soluble in alcohol (sp. gr. 0·794–0·800) contains the vesicating principle, while the insoluble portion is entirely non-vesicant, but contains the purgative constituents. He attributes the purgative properties to the combined non-volatile fatty acids, and chiefly to those which have the lowest melting points, and which are also the least saponifiable.

Colza and Rape Oils are practically identical. They are extracted from the seeds of *Brassica campestris*, var. *Oleifera*, or *Colza de printemps*, a variety of *Brassica campestris* (Linn.). The seeds are called cole-seed or rape-seed. Colza may be regarded as a superior sort of rape oil, the term "colza oil" being commonly applied to ordinary refined rape oil. Its specific gravity varies somewhat—from 0·912 to 0·920—but a fair density is 0·9136 at 60° F. It congeals at 21° F. (– 6° C.). Its colour is yellowish, or brownish yellow. It is sparingly soluble in cold, but readily soluble in hot, alcohol. It is largely used for burning in lamps, for lubricating purposes, and also in the manufacture of india-rubber.

Gingelly Oil.—*Syn.* TEEL OR TIL, BENNÉ OIL, OR SESAMÉ OIL.—The plant which yields this oil is called *Sesamum orientale* (or *indicum*), and is much cultivated in India. The seeds yield about 45 per cent. of oil. Its specific gravity is 0·923. Its presence, to the extent of not less than 10 per cent., may be recognized when mixed with other oils by the test given under the head of ALMOND OIL. It may be used instead of olive oil, and, according to PEREIRA, for almond oil.

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* "Pharm. Journ." [3] xiv. 416, 447.

Ground-nut Oil.—*Syn.* ARACHIS OIL.—Obtained from the seeds of *Arachis hypogæa* (ground nut, earth nut, or pea nut) by cold or hot pressure. The cold-drawn oil is nearly colourless, and resembles olive oil in flavour. Its specific gravity is about 0·916 at the usual temperature. It is used in making soap, as a lubricant, as a substitute for olive oil in many cases, and as an ingredient in artificial butter.

Horse-chestnut Oil.—From the fruit of *Æsculus hippocastanum.* It has a brownish-green colour, and keeps well. On the Continent it is used medicinally.

Mustard Oil.—*Syn.* OLEUM SINAPIS.—Three species of mustard are grown for the preparation of mustard, and each of these is capable of furnishing an oil by expression of the seeds :—

1°. *White mustard oil.*—From *Sinapis alba,* or white mustard, but chiefly from *Sinapis arvensis, S. chinensis, S. dichotoma, S. glauca, S. ramosa,* and *S. tori.* The yield is about 22 per cent. of the seed. Its specific gravity is 0·9142.

2°. *Black mustard oil.*—OLEUM SINAPIS NIGRI.—The seeds yield about 23 to 30 per cent. of oil by expression. It is viscid, and has stimulant properties, which make it useful as an application in rheumatism. Specific gravity, 0·921.

3°. *Wild mustard oil.*—*Syn.* OLEUM RAPHANI.—Obtained from seeds of *Raphanus raphanistrum.* From these seeds about 30 per cent. of oil is expressed.

From black mustard seed a volatile oil can be produced (*see under* VOLATILE OILS).

Mustard oils (fixed) vary in specific gravity from about 0·921 to 0·9142. They chiefly consist of glycerides of stearic, oleic, and brassic or erucic acids.

Nutmeg Oil (Expressed).—*Syn.* EXPRESSED OIL OF MACE, BUTTER OF NUTMEG OR MACE, OLEUM MYRISTICÆ (CONCRETUM) (Ph. L.), MYRISTICÆ ADEPS (Ph. E.), M. BUTYRUM, OLEUM MYRISTICÆ EXPRESSUM (B. P.).—The concrete oil expressed from the seed of *Myristica officinalis*, or common nutmeg. The nutmegs are beaten to a paste, enclosed in a bag, exposed to the vapour of hot water, and then pressed between heated iron plates. The product is orange coloured, fragrant, and spicy, and of a butyraceous or solid consistence. It is a mixture of the fixed with about 6 per cent. of the volatile oil of nutmeg. When discoloured and hardened by age, it is called "Banda soap" (OL. MACIS IN MASSIS). When pure, it is soluble in 4 parts of hot alcohol and in 2 parts of warm ether. Among other glycerides, it contains a large proportion of *myristin*. It has been used in rheumatism and palsy, but is now chiefly employed for its odour and aromatic qualities. It is chiefly imported from Singapore. Nutmegs yield from about 17 to 28 per cent. of this fat.

Olive Oil.—*Syn.* SALAD OIL, SWEET OIL, OLIVÆ OLEUM (B. P.), OLEUM OLIVARUM, OLEUM OLIVÆ (Ph. L., E., & D.), L.—The "oil expressed from the fruit" of *Olea europæa*, Linn. (Ph. L.), or common olive. Five different methods are employed to obtain the oil from the fruit:—

1. (VIRGIN OIL, O. O. VIRGINEUM, L., HUILE VIERGE, Fr.) From olives, carefully garbled, either spontaneously or only by slight pressure, in the cold. That yielded by the pericarp of the fruit is the finest.

2. (Ordinary "FINE OIL.") This is obtained by either pressing the olives, previously crushed and mixed with boiling water, or by pressing, at a gentle heat, the olives from which the virgin oil has been obtained. The above

processes furnish the finer salad oils of commerce. The cake which is left is called "GRIGNON."

3. (SECOND QUALITY.) By allowing the bruised fruit to ferment before pressing it. Yellow; darker than the preceding; but mild and sweet tasted. Much used for the table.

4. ("GORGON.") By fermenting and boiling the pressed cake or marc in water, and skimming off the oil. Inferior.

5. (OIL OF THE INFERNAL REGIONS, OLEUM OMPHACINUM.) Is a very inferior quality of oil, which is skimmed off the surface of the water in the reservoirs into which the waste water which has been used in the above operations is received, and allowed to settle. The last two are chiefly used for lamps, and in soap-making, &c.

Of the principal varieties of olive oil known in commerce, and distinguished by the place of their production, "PROVENCE OIL" is the most esteemed; "FLORENCE OIL" and "LUCCA OIL" are also of very fine quality; "GENOA OIL" comes next, and then "GALLIPOLI OIL," which forms the mass of what is used in England; "SICILY OIL," which has a slightly resinous flavour, is very inferior; and "SPANISH OIL" is the worst imported.

Olive oil is a nearly inodorous, pale greenish-yellow, unctuous fluid, with a purely oleaginous taste, peculiarly grateful to the palate of those who relish oil. It does not suffer active decomposition at a heat not exceeding 600° F.; and when cooled to 32° F. it congeals into a granular solid mass. It is very slightly soluble in alcohol, but its solubility is increased by admixture with castor oil. It is soluble in 1½ part of ether. When pure, it has little tendency to become rancid. Sp. gr. varies from about ·914 to 0·918 at 60° F. (15·5° C.). *Prod.* 32 per cent., of which 21 per cent. is furnished by the pericarp, and the remainder, which is inferior, by the seed and woody matter of the fruit.

Olive oil being, with the exception of almond oil, the most costly of the fixed oils of commerce, is consequently very subject to adulteration. Nut, poppy, rape, lard, and cotton-seed oils are very common adulterants. Refined tallow olein, including that obtained from the knackers' yards of Paris, is said to have been used in the same way. The addition of any other oil to olive oil renders it far less agreeable to the palate, and, by increasing its tendency to rancidity, makes it more likely to offend and derange the stomachs of those who consume it. When pure and fresh, olive oil is most wholesome as an article of food, or as a condiment.

In addition to the specific gravity of a sample, the following tests will aid n forming an opinion as to purity:—

1°. Olive oil loses its transparency and begins to solidify at 32°–50° F. (0°–10° C.) and is completely solidified when a small vessel containing it is surrounded by ice or a freezing mixture; but when mixed with poppy oil, it remains partly liquid even when the latter forms only one-fourth of the mass; if more than one-third of poppy oil is present, it does not solidify at all, unless cooled much below 32° F. (0° C.).

2°. The elaïdin test, described in Chapter IX., is a very useful one in the examination of olive oil. If pure, it becomes, in three or four hours after the application of the test, like a firm fat, without any separation of liquid oil, and, after twenty-four hours, the mass will be found so hard that some little force must be employed to push a glass rod into it. The other edible oils do not behave in this way. The solidity of the mass is inversely proportionate to the quantity of foreign oil present. When the sophistication is equal to one-eighth of the whole a distinct liquid layer separates; when the sample contains half its volume of an inferior oil, one-half only of the mixture becomes solid, and the other half continues liquid. When the adulterant is an animal oil, the mixture solidifies in about five hours, but in this case the coagulum contains the animal oil, whilst the olive oil floats on the surface, and may be decanted for further examination. The coagulum in this case, when heated, exhales the odour of rancid fat or melted tallow.

3°. Dr. **Ramon Cordina Langlies** recommends the following test for the examination of olive oil:—

Mix 3 gms. of the oil to be tested with 1 gm. of nitric acid (3 of nitric acid to 1 of water) in a test tube, or small stoppered flask, and heat in a water-bath. If the oil is pure, the mixture becomes clearer, and takes a yellow colour, like purified oil; if it is adulterated with seed oil, it acquires the same transparency as the pure oil, but becomes *red.* With 5 per cent. of seed oil, the reddish colour is perceptible; with 10 per cent., it is decided. This reaction does not require more than from fifteen to twenty minutes for its development. The colouring lasts for three days.

4°. **Bach's** method of testing olive oil.[*]

a. Nitric-acid test.—5 c.c. of the sample are shaken in a convenient tube with 5 c.c. of nitric acid of sp. gr. 1·30 for one minute, and the resulting colour observed, (*a*) after one minute, and (*b*) after standing five minutes in boiling water, and (*c*) the consistence noted after standing for twelve to eighteen hours at about 60° F. (15·5° C.).

	Colour.		Consistence.
	One minute.	Five minutes.	
Pure olive oil	Pale green	Orange yellow	Quite solid
Cotton-seed ,,	Yellowish brown	Reddish brown	Salve-like or smeary
Sesamé ,,	White	Brownish yellow	Perfectly liquid
Sunflower ,,	Dirty white	Reddish yellow	—
Ground-nut ,,	Pale rose	Brownish yellow	Quite solid
Rape-seed ,,	,,	Orange yellow	Quite solid
Ricinus ,,	,,	Golden yellow	Salve-like or smeary

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[*] "*Amer. Journ. Pharm.*" 1883, 354.

Mixtures of olive oil with small amounts of cotton-seed and sesamé oils are distinguished by the entire mass, though at first *more darkly coloured* and solidifying like pure olive oil, yielding, after from twenty-four to thirty-six hours, a brown oil upon the surface of the firmly solidified mass, whilst the lower layer shows the yellow colour of the pure olive oil. Oils which have been treated with alkalies show the same reactions as the pure oils.

b. Melting point of the fatty acids.—This may be obtained by the process described in a subsequent chapter. As, however, the melting point of fats and fatty acids is apt to vary according to the method employed, to obtain figures comparable with those of Bach it will be advisable to follow the details recommended by him. His process is as follows:—A small test tube containing the fatty mass is placed in a beaker filled with water, and heated by a small flame. A thermometer is dipped into the fatty acids, gently stirred about during the observation, and the temperature noted when the entire mass becomes perfectly clear. This is the melting point. The flame is removed, and, when clouds begin to form about the bulb of the thermometer, the temperature is again observed. This is the solidifying point. The following are the results obtained by Bach in this way:—

The Fatty Acids of	Melt at (Cent.)	Solidify at (Cent.)
Pure olive oil......	26·5–28·5°	Not lower than 22°
Cotton-seed „	38·0°	35·0°
Sesamé „	35·0°	32·5°
Ground-nut „	33·0°	31·0°
Sunflower „	23·0°	17·0°
Rape-seed „	20·7°	15·0°
Ricinus „	13·0°	2·0°

The melting and solidifying points of olive oil deviate so far from those of the other oils that adulteration with them, to the extent usually occurring in commerce, is said to be thus readily detected. The following cases of adulteration are given :—

Fatty Acids from Mixture of	Melt at (Cent.)	Solidify at (Cent.)
Gallipoli olive oil + 20 per cent. Sunflower oil	24°	18°
Nizza „ „ + 20 „ Cotton-seed „	31·5°	28°
Gallipoli „ „ + 33⅓ „ Rape-seed „	23·5°	16·5°
„ „ „ + 50 „ „ „	20°	13·5°

5°. Bechi's method of detecting cotton-seed oil in olive oil.[*]

Bechi finds the following method to give good results :— 5 c.c. of the sample are mixed with 25 c.c. alcohol of 98 per cent., and 5 c.c. of a silver-nitrate solution (1 gm. of the nitrate in 100 c.c. of 98 per cent. alcohol). The mixture is heated to 84° C. If cotton-seed oil be present, even in very small quantity only, the mixture will become coloured, and take a tint more or less deep according to the amount of cotton-seed oil present. This method depends on the property possessed by cotton-seed oil of reducing silver nitrate. It is necessary to avoid heating by a direct flame, or other oils which may be present, such as linseed oil, colza, &c., will give colorations.

6°. Renard's method of detecting earth-nut oil in olive oil.[†]

The oil is saponified, and the resulting soap decomposed by hydrochloric acid. The fatty acids which separate are then converted into lead salts, and the oleate of lead removed by ether. The remaining lead salts are then decomposed by hydrochloric acid, and the fatty acids obtained are dissolved in alcohol of 90 per cent., and the solution is left to cool. If earth-nut oil is present, abundant crystals of arachidic acid will soon be seen to form. The crystals are washed in alcohol of 70 per cent., in which they are perfectly insoluble, dissolved in boiling absolute alcohol, and the solution is evaporated to dryness and weighed. In reckoning the amount of arachidic acid obtained, allowance must be made for the quantity dissolved by the alcohol. 100 parts of 90 per cent. alcohol dissolve 0·25 of arachidic acid. The process does not succeed with a mixture containing less than 4 per cent. of earth-nut oil, but M. RENARD states that with a 10 per cent. mixture the proportion of the adulterant may be ascertained within 1 per cent. of the truth.

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[*] "Journ. Pharm." [5] ix. 35-36.

[†] "Compt. Rend." lxxiii. 1330.

7°. The following tests for the detection of the presence of linseed, sesamé, and colza oils in olive oil have also been proposed: *—

Linseed.—2 c.c. nitric acid are mixed with 5 c.c. of the sample, and a piece of bright copper wire is introduced into the mixture. If after half an hour the wire has acquired a rose colour, the olive contained linseed oil.

Sesamé.—An equal quantity of hydrochloric acid (23° B.) is added, and a fragment of cane sugar dissolved in the mixture. If, after shaking and standing, a red colour is developed, sesamé oil is indicated.

Colza.—10 gms. of the sample are saponified with alcoholic potash (free from sulphur). If there is a darkening in colour, it shows the probable presence of colza oil.

The dietetical uses of olive oil are well known. In Spain and Italy it is commonly employed as a substitute for butter. It is highly nutritious, but is digested with difficulty by some persons, and hence should be avoided by the dyspeptic. Like almond oil, it is occasionally employed as a laxative and vermifuge, and is, perhaps, one of the mildest known. In pharmacy it is extensively employed in the preparation of cerates, liniments, ointments, and plasters. *Dose*, for an adult, ½ to 1 wineglassful as a mild aperient; for an infant, ½ to 1 teaspoonful mixed up with an equal quantity of honey, syrup of roses, or syrup of violets. The white fibrous sediment which forms in the recently expressed oil is the *Amurca* of Pliny, and was formerly highly esteemed in medicine.

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* "Arch. Pharm." iii. 23, 280; "Journ. Soc. Chem. Ind." 1885, 601.

The commoner kinds of the oil are used for lubricating, illuminating, dressing of wool, and for soap-making. As a lubricant and illuminant, its value is liable to serious depreciation, according to Mr. L. ARCHBUTT, F.C.S., from excessive quantities of free oleic acid. In 89 samples Mr. ARCHBUTT found the proportion of acidity (expressed as oleic acid) to vary on the average from 5·3 to 12·2 per cent., and when the amount exceeded about 3 to 5 per cent., the oil was found, when burnt in lamps, to have a great charring action on the wicks.*

Olive Oil Droppings.—*Syn.* SWEET OIL DROPPINGS.—The "foots," or "droppings" and "drippings" of the casks, cisterns, and utensils used in the storage of olive oil. It is used for machinery, making soap, &c.

Palm Oil.—*Syn.* PALM BUTTER, OLEUM PALMÆ.—This oil is obtained from the fruit of several species of palm, chiefly of *Elœis guineensis*. The nuts or fruit, after separation from the spadices containing them, are allowed to decompose to a certain extent in the open air. By pounding with wooden pestles, the pulp is then detached from the hard nuts, mixed with a little water, and heated.

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* "Analyst," Sept. 1884.

The oil is then forced out by pressure. This process does not free the oil from all fragments of pulp, and hence it has a great tendency to become rancid and acid. Fresh palm oil has an orange-yellow tint, a sweetish taste, and an odour somewhat resembling that of violets or orris root. It is of the consistence of butter or lard. Its melting point varies greatly—from 76° to 95° F. It is bleached by exposure to sunlight, chlorine, chromic acid, and sulphuric acid. Specific gravity, about 0·968. It is soluble in ether and in alcohol of specific gravity 0·848. Mr. ARCHBUTT found a very large proportion of free fatty acid in several samples examined by him, varying from 12·0 to 79·0 per cent. calculated as palmitic acid. It is used in candle and soap making, and also to colour and scent ointments, pomades, soap powders, &c. "Lagos" oil generally is most neutral, and "Brass" oil hardest of the several kinds imported.

PALM-NUT, OR PALM-NUT KERNEL, OIL is extracted from the nuts or kernels of the fruit. It has a primrose-yellow colour, and an odour like that of cocoa-nut oil. It is often used instead of the latter in soap-making, and contains, like it, both fixed and volatile acids.

Piney Oil.—*Syn.* PINEY TALLOW, P. DAMMAR, P. RESIN.—To prepare this oil, the seeds of *Vateria indica*, or Piney tree, are roasted, then ground, and boiled with water. The oil is skimmed off. When cold, it is a solid fat, which melts at about 95° to 97° F. (35°–36° C.) Its specific gravity is about 0·926. Its colour is white, and it has a somewhat fragrant odour. It is made into candles.

Rape-seed Oil.—*Syn.* COLZA OIL, BROWN OIL, OLEUM RAPÆ.—This is identical with colza oil (*see above*). Refined or pale rape oil is prepared from the crude oil by agitating it with 2 per cent. of oil of vitriol previously diluted with about twice its weight of water, and after ten or twelve days' repose, decanting the clear oil, and filtering it through Canton flannel or felt. The quality is improved by washing it with water or steaming it before filtration. It is used for lamps, blacking, and machinery; and also for adulterating both almond and olive oils. It is the common "sweet oil" of the oilmen and druggists. Usual specific gravity, about 0·913–·915.

Sesamé Oil.—*See* GINGELLY OIL.

Teel or Til Oil.—*See* GINGELLY OIL.

Turkey-red Oil.—This oil is the soluble product obtained by the action of sulphuric acid on different oils. It may be prepared by mixing castor oil with sulphuric acid diluted with one-third of its bulk of water, and leaving the mixture over night. It is then washed, to remove the acid, with water containing common salt, and the fatty acids are saponified with ammonia, either alone or with potash or soda. FREMY long ago investigated the action of sulphuric acid on olive oil; and the use of sulpholeic acid for preparing cotton tissues was first proposed by RUNGE in his book on the chemistry of colours, published in 1834. In 1876 the sulpholeic acid from castor oil was introduced with marked advantage. According to MÜLLER-JACOBS, Turkey-red oil is a mixed solution of sulpholeic acid, $C_{18}H_{33}(SO_3H)O_2$ (soluble in water), hydroxyoleic acid ($C_{18}H_{34}O_3$), and hydroxystearic acid ($C_{18}H_{36}O_3$) (soluble in alcohol), and unaltered oil, or triglyceride (soluble in ether). When sulpholeic acid is boiled with water, the following decomposition, according to H. SCHMID,* takes place:—

$$\underbrace{2C_{18}H_{34}SO_5}_{\text{Sulpholeic acid}} + \underbrace{2OH_2}_{\text{Water}} = \underbrace{SO_4H_2}_{\text{Sulphuric acid}} + \underbrace{SO_2}_{\text{Sulphurous anhydride}} + \underbrace{C_{18}H_{34}O_3}_{\text{Hydroxyoleic acid}} + \underbrace{C_{18}H_{36}O_3}_{\text{Hydroxystearic acid}}$$

MÜLLER-JACOBS considers that the action of Turkey-red oil as a mordant is due to its yielding oil to the fibre in a finely divided form, and, in the best processes, the remaining sulpholeates are said to be removed by washing. Liechti and Suida, however, state that many more experiments require to be made before the chemical changes which take place in this process are completely understood. Müller-Jacobs says that the strongly diluted solution of Turkey-red oil treated with aqueous ammonia until it has an alkaline reaction should remain clear, and show no turbidity after the lapse of some hours. The turbidity would be caused by the presence of more or less considerable quantities of solid fats, or their glycerine ethers (palmitin and stearin), and proves that either very impure castor oil, or generally other crude oils, such as rape-seed oil, sesamé oil, blubber oil, cotton-seed oil, olive oil, were employed for the preparation of the red oil in question.

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* "Dingl. Polyt. J." 254, 346–350; "J. Soc. Chem. Ind." 1883.

Formerly the oil used in Turkey-red dyeing was Gallipoli oil (Huile tournante), but this has now to a great extent been superseded by the preparations above noticed.

Watchmaker's Oil.—Prepared by placing a clean strip or coil of lead in a small white-glass bottle filled with pure almond or olive oil, and exposing it to the sun's rays for some time till curdy matter ceases to deposit and the oil has become quite limpid and colourless. It does not become thick by age, and hence is suitable for fine work. Specific gravity, 0·916–0·917.

Chaulmoogra Oil.—*Syn.* Lukrabo oil.—From *Gynocardia odorata*, a native of India. It contains palmitic and gynocardic acids, and, according to Messrs. Naylor and Mass, cocinic acid. Solid at 60° F. Melts about 108° F. Specific gravity 0·930. Both the oil and gynocardic acid have been used with success in skin diseases. In eczema, Dr. W. Cottle has found an ointment made of gynocardic acid 15 to 25 grains, vaseline 1 oz., almost a specific.

CHAPTER IV.

VEGETABLE OILS.

(*b*) VOLATILE.

Syn. OLEA DESTILLATA, OLEA DISTILLATA, OLEA ESSENTIALIA, OLEA VOLATILIA, L., HUILES VOLATILES, Fr.—The volatile oils derived from the vegetable kingdom are an extensive and important class of bodies, found in almost every part of the majority of the plants which produce them, except the cotyledons of the seeds, in which, in general, the fixed oils are exclusively stored up. Their presence confers upon flowers, leaves, fruit, seeds, roots, bark, and woods their peculiar and characteristic odours; but among these they are not equally distributed in the same individual, and are often altogether absent from some of them. To them we are indebted for our most delightful perfumes and our choicest spices and aromatics. Some of them are found to possess valuable medicinal properties, and others are invested with the highest possible interest on account of their peculiar chemical constitution, and the reactions which occur when they are brought into contact with other bodies.

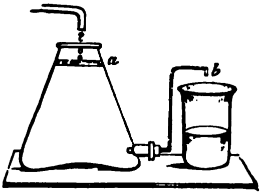
The volatile oils are often called "essences," and the same term is also commonly applied to their alcoholic solutions. Although essential oils are volatile, volatile oils are not always essential ones as the term is understood. For instance, the petroleum and paraffin oils obtained by the distillation of native petroleum and bituminous bodies, though not *essential*, are *volatile* oils. To describe the two as synonymous is therefore incorrect.

Preparation.—The volatile vegetable oils are procured in several ways:—(1°) By distillation; (2°) By absorption or "enfleurage;" (3°) By means of solvents; (4°) By expression; (5°) By maceration.

(1°) *Distillation.*—According to the common method of proceeding, substances which part freely with their oil are put into the still along with about an equal weight of water, and are at once admitted to distillation. Those substances which give out their oil with difficulty are first soaked for twenty-four hours, or longer, in about twice their weight of water, to each gallon of which 1 lb. of common salt has been added, in order to raise its boiling point. The distillation is conducted as quickly as possible, and when one-half the water has come over, it is returned into the still, and this cohobation is repeated, when necessary, until the distilled water ceases to be mixed with oil. The heat of steam, or a salt-water bath, should be preferably employed. When a naked fire is used, the still should be deep and narrow, by which means the bottom will be better protected by the gradually decreasing quantity of water towards the end of the process, and empyreuma prevented. When the distilled water is to be repeatedly cohobated on the ingredients, a convenient and economical plan is to so arrange the apparatus that, after the water has separated from the oil in the receiver, it shall flow back again into the still. An ordinary worm-tub, or other like condensing apparatus, may be employed; but, in the case of those oils which readily solidify, the temperature of the water in the condenser must not fall below about 55° F.

The mixed vapours which pass over condense and fall as a milky-looking liquid into the receiver. This separates after a time into two portions, one of which is a solution of a part of the newly eliminated oil in water, and the other is the oil itself. The latter either occupies the upper or the lower portion of the receiver, according as its specific gravity is less or greater than that of distilled water. The separation of the oil and water is effected by allowing the mixed liquids to drop into a "Florentine receiver" (Fig. 1), when the oil is the lighter of the two, by which means the latter accumulates at *a*, and the water flows over by the spout *b*.

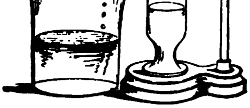
FIG. 1.



The same receiver may be employed for oils heavier than water, by reversing the arrangement; but a glass "separator" (Fig. 2) is, in general, found more convenient. In this case the oil accumulates at the bottom of the vessel, and may be drawn off by the stopcock provided for the purpose.

In 1836, the London College gave the following directions for the preparation of the essential oils: "The fruit of anise, caraway, and juniper, the flowers of chamomile, lavender, and elder, the berries of allspice, the tops of rosemary, and the entire recent plants of the other herbs are to be employed." "Put any one of these into an alembic, then pour in as much water as will cover it, and distil the oil into a large vessel kept cool." (Ph. L. 1836.) But these were excluded from the Pharmacopœia of 1851, on the ground that these substances are seldom prepared by the druggist or apothecary.

FIG. 2.



The Edinburgh College directs—"As much water only is to be employed as will prevent empyreuma during the distillation. The distillation may be immediately commenced after a proper maceration, and the oil afterwards separated from the water," in the manner already noticed.

"It is also necessary to observe, in preparing these oils, as well as the distilled waters, that the quality of the substances, their texture, the season of the year, and similar circumstances must occasion so many differences that it is scarcely possible to give any certain and general rules which shall strictly apply to every example. Many things, therefore, must be regulated by the judgment of the operator."

The Dublin College directs the vegetable substances to be macerated in the still with about 5 times their weight of water, for twenty-four hours, when one-half of the water is to be drawn over. The oil having been separated from this in the usual manner, it is to be returned to the still, and the same quantity drawn over as before, from which the oil must again be separated.

CHEVALLIER gives the following rules for the distillation of essential oils:—

1. Operate upon as large quantities as possible, in order to obtain a greater product, and one of finer quality.

2. Conduct the distillation rapidly.

3. Divide the substances minutely, in order to facilitate the extrication of the oil.

4. Employ only sufficient water to prevent the matter operated on from burning, and the product from being contaminated with empyreuma.

5. For substances whose oil is heavier than water, saturate, or nearly saturate, the water in the still with common salt, to raise the boiling point, and thus to enable the vapour to carry over more oil.

6. Employ, when possible, water which has been already

distilled from off the same substances, and has thus become saturated with oil.

7. For oils naturally fluid, keep the water in the refrigerator cool; but for those oils which easily become solid, preserve it at 80° to 90° F.

To the above may be added—

8. Collect the oil as soon as possible after it separates from the water with which it passes over, and in its subsequent treatment keep it as much as possible from free contact with the air.

Dr. URE remarks: "The narrower and taller the alembic is, within certain limits, the greater will be the proportion of oil, relative to that of the aromatic water, from like proportions of aqueous and vegetable matter employed." "Some place the plants in baskets, and suspend these immediately over the bottom of the still, under the water, or above its surface in the steam; but the best mode, in my opinion, is to stuff an upright cylinder full of the plants and drive down through them steam of any desired force, its tension and its temperature being further regulated by the size of the outlet orifice leading to the condenser. The cylinder should be made of strong copper, tinned inside, and encased in the worst conducting species of wood, such as soft deal or sycamore."

The newly distilled oils may be separated from adhering water, which frequently renders them partially opaque or "cloudy," by repose at a temperature between 60° and 70° F., and subsequent decantation; but to render them quite dry (anhydrous), it is necessary to let them stand over some fragments of fused chloride of calcium. This is not, however, required with the commercial oils.

(2°) *Absorption or "enfleurage."*—The odours of some flowers, such as jessamine and mignonette, are too delicate to bear heat, and for these the process of absorption is employed. Sheets of glass in wooden frames, called *chassis*, are coated on their upper and lower surfaces with grease about a tenth of an inch in thickness. The flowers are spread upon this grease, and a number of frames are superimposed on each other. After a day or two the flowers are carefully removed, and replaced by fresh ones, and this is continued for two or three months till the fat is impregnated with the odours. It is then removed, and extracted with alcohol.

Recently the grease has been replaced in some cases by paraffin, glycerine, or vaseline.

(3°) *Solvents.*—For this process various solvents are used, such as alcohol, ether, chloroform, petroleum, bisulphide of carbon, &c., and the oil is extracted by these in a percolator.

(4°) *Expression.*—The essential oils of lemons and oranges of commerce, and of some other fruits, are chiefly obtained by submitting the yellow rind to powerful pressure; but in this way they are not so white, nor do they keep so well, as when distilled, although in the case of the fruits referred to the oils are more fragrant than when prepared by any other method.

This process is only adapted for substances which are very rich in essential oil.

(5°) *Maceration.*—Flowers with very delicate perfume, such as those of the bitter orange, violets, &c., which would be spoilt by distillation, are treated by this method. The medium used for infusion is clarified beef or mutton suet, or lard. The fat is melted, the flowers immersed, and the mixture stirred occasionally for a day or so. The exhausted flowers are removed and fresh ones introduced, and such renewals are continued till it is judged that the fat is sufficiently charged with the oil.

Rectification.—This is commonly performed without water, by the careful application of a heat just sufficient to make the oils flow over pretty rapidly, so that they may be kept heated for as short a time as possible. One-half, or at most two-thirds only, is drawn off, that left in the retort being usually mixed with raw oil intended to be sold in that state. This methŏd often leads to much loss and disappointment, and more than one rather dangerous explosion has been known to result from its use. A better plan is to rectify the oil from strong brine, and then to separate any adhering water, either by repose or chloride of calcium.

Volatile oils should be preserved in well-closed and nearly full bottles, in the shade, and should be opened as seldom as possible. By age they darken, lose much of their odour, increase in density, and become thick and clammy. It is then necessary to distil them, by which the undecomposed portion is separated from the resin. Agitation along with animal charcoal will restore their clearness and original colour, but nothing more.

Prop. The volatile or essential oils are usually more limpid and less unctuous than the fixed oils, but some of them are butyraceous or crystalline. Nearly all of them consist of two or more oils, differing in their sp. gr. and boiling points, one of which is generally liquid, the other, in some cases, crystalline. All of them, when perfectly pure, are colourless, though before rectification nearly the whole of them have a pale yellow tint, and some of them are brown, blue, or green. Their odour is that of the plants which yield them, and is usually powerful; their taste is pungent and burning. They mix in all proportions with the fixed oils, dissolve freely in both alcohol and ether, and are sparingly soluble in water, forming "perfumed" or "medicated waters." Their boiling point usually ranges between 310° and 325° F., and is always considerably higher than that of water. They resist saponification, and (excepting oil of cloves) do not combine with the salifiable bases. Their density fluctuates a little on either side of water. The lightest oil is that of citrons (sp. gr. ·847), and the heaviest that of winter green (sp. gr. 1·173). When cooled sufficiently, they all solidify. The common temperature of the atmosphere is sufficient for this with some of them, as the oils of roses and aniseed; whilst others require to be cooled below the freezing point of water before they assume the solid form. In this state they appear to consist of a crystalline or semi-crystalline substance (stearoptene, stear-essence), and a fluid portion (elæoptene, olei-essence). The two may be separated by pressing the concrete oil between the folds of bibulous paper, in the cold. By exposure to the air, the volatile oils rapidly absorb oxygen, and become partially converted into resin. This is the cause of the deposit that usually forms in them (especially in the expressed oil of orange) when kept in an ill-corked vessel. The solid crystalline matter which separates from them when kept in closed vessels is stearoptene.

Chemically considered, the essential oils may be divided into three classes:—

1. Oils composed of carbon and hydrogen only (binary volatile oils, hydrocarbons, terebenes, camphenes), of which oil of turpentine may be regarded as the type. These are characterized by being, as a class, less soluble in rectified spirit and in water than the other essential oils. The oils of bergamot, capivi, cubebs, elemi, hops, juniper, lemons, orange peel, pepper, the grass oil of India, the laurel oil of Guiana, and some others belong to this class.

2. Oils containing carbon, hydrogen, and oxygen (oxygenated oils), including most of those used in medicine and perfumery. These, as a class, are more soluble in rectified spirit and in water than those containing carbon and hydrogen only. To this class belong the oils of almonds,

aniseed, cassia, cedar-wood, cinnamon, cumin, jasmin, lavender, meadowsweet (*Spiræa ulmaria*), orange flowers, pennyroyal, peppermint, spearmint, rosemary, rose-petals, valerian, winter green (*Gaultheria procumbens*), and others too numerous to mention. A few of these oxygenated oils contain nitrogen.

3. Oils containing sulphur (sulphuretted oils). These are characterized by their extreme pungency, suffocating odour, vesicating power, property of blackening silver, and being decomposed by contact with most other metallic bodies. The oils of assafœtida, black mustard seed, garlic, horseradish, and onions are of this kind. Some sulphuretted oils contain nitrogen.

Uses, &c.—The volatile oils are chiefly used by perfumers and rectifiers, and in medicine. Some of the cheaper kinds are largely employed as vehicles for colours, and in the manufacture of varnishes. The dose of the aromatic and carminative oils is from 1 to 10 drops, on sugar, or dissolved in a little weak spirit. This does not apply to oil of bitter almonds, the dose of which is ¼ to ½ a drop.

⁂ The following list includes short notices of nearly all the volatile oils which have been examined, as well as of some other substances of a similar character which commonly pass under the name.

These will be most conveniently studied if classed according to the natural orders of the plants from which they are derived:—

Class, THALAMIFLORÆ.

Natural Order, *Anonaceæ*.

Ilang-Ilang Oil.—*Syn.* CANANGA OIL, OLEUM ANONÆ, OLEUM UNONÆ.—The flowers of *Cananga odorata*—the *Uvaria odorata* of ROXBURGH and the earlier Indian botanists—

yield this oil. It is interesting as containing benzoic ether. FLÜCKIGER has shown that it also contains a phenol-like body, and an aldehyde or ketone.

Natural Order, *Aurantiaceæ.*

Bergamot, Oil of.—*Syn.* ESSENCE OF BERGAMOT, OLEUM BERGAMII, O. BERGAMOTÆ.—Prepared by expression, or expression and scarification, from the rind of the *Citrus bergamia*, or bergamot orange. It is of a pale-greenish colour, and highly fragrant. It is obtained purer by distillation, but its perfume is then less delicate. Its specific gravity varies from 0·86 to 0·885. The rind of 100 bergamot oranges will yield nearly 3 oz. of oil (M. RAYBAUD). It is very frequently adulterated—with rectified spirit, or with oil of lemons, orange, or turpentine. The presence of these substances will be found to be indicated by the methods given under TESTING OF OILS. It may be here mentioned that pure bergamot oil is *much more soluble* in rectified spirit than either of the adulterants specified, and it dissolves completely in solution of potash. Its chief use is in perfumery, but it has been recently recommended * as a reliable and quick acting remedy for scabies.

Cedrat Oil.—*Syn.* ESSENCE OF CEDRA, OLEUM CEDRI, O. CITRI FINUM, L.—From the exterior yellow rind of the fruit of *Citrus medica*, or citrons, either by expression or distillation, as oil of bergamot. The first portion of oil that comes over is colourless; the latter portion greenish. Very fragrant. Specific gravity, ·847. *Prod.* 100 citrons yield nearly 1 fl. oz. of pale and ½ fl. oz. of green oil.

Citron Oil.—*Syn.* ESSENCE OF CITRON, OLEUM CITRI.—Obtained from the lees of citron juice, or from the peel of citrons. The latter generally goes by the name of oil of cedrat. Both are fragrant.

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* "Pharmaceut. Zeitung," 1881, 306.

Lemons, Oil of.—*Syn.* Essence of L., Oleum limonis (B. P.), Oleum limonis, O. limonum (Ph. L., E., & D.).—From the yellow portion of the rind, grated, placed in hair bags, and exposed to powerful pressure; also by distillation, but the product is then less agreeably fragrant and sweet, though it keeps better. Nearly colourless; odour that of the fruit. Specific gravity, ·8752 to ·8785. Expressed oil, ·8517, distilled oil, ·845, at 72° F. (Ure). *Prod.* 100 lemons yield, by expression, 1¾ to 2 oz. (nearly); by distillation, 1¼ to 1½.

It is commonly adulterated with oil of turpentine, and occasionally with nut or poppy oil. When pure, it is soluble in all proportions in absolute alcohol, but rectified spirit only dissolves 16 per cent. of it. It also boils at 148° F., whereas oil of turpentine boils at 312°, and mixtures of the two at intermediate temperatures, depending on the proportions. G. Heppe * tests for turpentine as follows:—A portion of the oil is gradually heated on a sand-bath in a perfectly dry test tube; with a small quantity of cupric butyrate (size of pin's head) to about 172° C. If the oil of lemons is pure, the copper salt dissolves and colours the oil green. If oil of turpentine be present, the oil becomes turbid, turns yellow, and deposits reddish-yellow cuprous oxide. Too much of the reagent must not be used; otherwise the oil will be green after cooling, even if oil of turpentine be absent.

Limes, Oil of.—*Syn.* Oleum limettæ, L.—From the rind of the fruit of *Citrus limetta*, or lime, as oil of lemons, which it somewhat resembles. *Prod.* 100 limes yield 2¼ to 2½ oz. of oil.

Neroli Oil.—*Syn.* Oil of orange flowers, Essence of neroli, Oleum naphæ, O. aurantii florum, Aurantii oleum (Ph. E. & D.).—Prepared from the flowers of either the bitter (Seville) or sweet orange (*Citrus vulgaris* or *C. aurantium*) by distillation with water. That from the fruit is said to be preferred, but there does not appear to be any actual difference between the two. It is very fluid, and lighter than water, in which it is slightly soluble. It is delightfully aromatic and fragrant, but the odour differs slightly from that of the flowers. 100 lb. of flowers gathered in May or December yield 3 to 6 oz. of oil; 6 cwt. of the fresh flowers yield 1 lb. of oil.

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* "Chem. Tech. Centr. Anz." iii. 371.

Neroli is commonly adulterated with alcohol or essence de petit grain, and often with both. The presence of the first is easily determined; that of the second can only be discovered by comparing the odour evolved during the evaporation of a drop of the suspected oil, placed on a piece of white paper with a like drop of pure neroli similarly treated.

Orange Oil.—*Syn.* ESSENCE OF ORANGE, OLEUM AURANTII, O. AURANTIORUM, O. AURANTIORUM CORTICIS.—Prepared from the yellow portion of the rind of either the Seville or sweet orange, preferably of the latter, in the same way as oil of bergamot, or of lemons. It closely resembles oil of lemons, but is more agreeably fragrant. The expressed oil is very apt to become opaque, and deposit a stearoptene, especially in cold weather, unless well kept from the air. Specific gravity, about 0·875. 100 fruits yield 4 to 5 oz.

Orange Berries, Oil of.—*Syn.* OLEUM AURANTII BACCÆ. —From the small unripe fruit of the orange tree. It does not keep well.

Orange Leaf Oil.—*Syn.* ESSENCE DE PETIT GRAIN, OLEUM AURANTII FOLII.—From the leaves of either the bitter or sweet orange—that from the first being preferred. It is delightfully fragrant. Extensively used to adulterate oil of neroli, and is itself commonly sophisticated with both alcohol and oil of orange berries.

Natural Order, *Caryophyllaceæ*.

Cajeput Oil.—*Syn.* CAJEPUTI OIL, KYAPOOTIE OIL, CAJEPUTI OLEUM (B. P.), OLEUM CAJAPUTI (Ph. L., E., & D.), L.—From the dried leaves of the *Melaleuca cajeputi* (*Melaleuca minor*, B. P.). Colourless, when pure (that of commerce is usually green); odorous; aromatic; taste, hot and penetrating. Its odour has been compared to a mixture of those of camphor and cardamoms. It boils at 343° F. Sp. gr. ·920 to ·927. When rectified, about three-fourths of the quantity passes over colourless, and has the density ·897; the remaining portion is green, and has the density ·920 to ·925. Its green colour is derived from a salt of copper, the presence of which may be recognized by the red precipitate occasioned by agitating the oil with a solution of ferrocyanide of potassium (GUIBOURT). From the East Indies.

Pure oil of cajeput is slightly soluble in water; entirely and freely soluble in alcohol; dissolves iodine; and when dropped on water, rapidly diffuses itself over the surface, and soon completely evaporates. A spurious kind (FACTITIOUS OIL OF CAJEPUT), made of oil of rosemary, flavoured with camphor and the oils of peppermint and cardamoms, and coloured with verdigris, is occasionally met with in the shops.

Oil of cajeput is a powerful antispasmodic and diffusible stimulant. *Dose*, 3 to 6 drops, on sugar; in cholera, colic, epilepsy, hysteria, rheumatism, spasms, toothache, &c.

Cloves, Oil of.—*Syn.* ESSENCE OF CLOVES, OLEUM CARYOPHYLLORUM, OLEUM CARYOPHYLLI (B. P., Ph. L., E., & D.), OLEUM EUGENIÆ CARYOPHYLLI (Ph. D. 1826), L.—Obtained from the *Caryophyllus aromaticus*, or Molucca clove tree, cultivated in Penang, Bencoolen, and Amboyna. The unexpanded flowers (cloves) and flower-stalks are soaked for some time in salt and water, and then submitted to distillation, the distilled water, after having deposited its oil, being returned three or four times into the still, and again "worked off" from the same materials. Nearly colourless, when recent, gradually becoming pale yellow, and ultimately light brown, by age; highly aromatic, with the characteristic odour and flavour of cloves. It is the least volatile of all the essential oils. Soluble in alcohol, ether and strong acetic acid. Specific gravity, 1·055 to 1·061 (1·034 to 1·061, B. P.). *Prod.* 16 to 22 per cent.

As a medicine it is stimulant and carminative. It is used as an adjunct to purgatives and as an application to carious teeth.

Oil of cloves is frequently adulterated with inferior essential oils, especially with those of pimento, pinks, and clove-gillyflowers, and, occasionally, with castor oil. The following methods have been recommended for testing its purity.—1. Pure oil of cloves forms a butyraceous coagulum when shaken with pure liquor of ammonia, which crystallizes after fusion by a gentle heat.—2. Treated with an alcoholic solution of potash, it entirely congeals into a crystalline mass, with total loss of its characteristic odour.—3. Shaken with an equal volume of strong caustic soda lye, it forms, on repose, a mass of delicate lamellar crystals.—4. Solution of chromate of potash converts it into brown flakes, whilst the salt loses its yellow colour.—5. Chlorine turns it first green, and then brown and resinous.—6. Nitric acid turns it red, and a reddish-brown solid mass is formed; with heat, it converts it into oxalic acid.—7. It dissolves freely in sulphuric acid, yielding a transparent, deep reddish-brown solution, without any visible decomposition.—8. Mixed, gradually, with about one-third of its weight of sulphuric acid, an acid liquor is formed, together with a resin of a rich purple colour, which, after being washed, is hard and brittle, and forms a red tincture with rectified spirit, which is precipitated of a blood-red colour by water.—9. It dissolves iodine freely, without any marked reaction.—10. It dissolves santaline freely.

11. M. Jacquemin recommends the following as a very delicate test for the presence of carbolic acid when used as an adulterant for oil of cloves:—One drop of the suspected oil is mixed with a very small quantity of solution of aniline by means of a glass rod, and then shaken with 5 or 6 c.c. of distilled water. By the addition of a few drops of sodium hypochlorite to the mixture the characteristic blue coloration due to carbolic acid will be developed in a few minutes if the adulterant is present, whereas, with the pure oil, nothing but the purplish-violet colour of aniline will be perceived. Stirring or shaking must be avoided after the addition of the hypochlorite. The presence of 1 per cent. of phenol can thus be demonstrated in 1 drop of the oil.

By distilling commercial oil of cloves from solution of potash, Ettling obtained two volatile oils—a light oil, sp. gr. 0·918, isomeric with oil of turpentine ($C_{10}H_{16}$), and a heavy oil (*caryophyllic* or *eugenic acid*, $C_{10}H_{12}O_2$). The latter remained in the retort, combined with the alkali, while the light oil passed over. On addition of phosphoric or sulphuric acid to the residue the heavier oil was liberated and also distilled off. Its sp. gr. was 1·079.

Artificial vanillin may be prepared from oil of cloves* in the following manner:—1°. The oil is diluted with three times its volume of ether, and agitated with a very dilute aqueous solution of potash. 2°. The resulting alkaline solution of eugenol is separated, the alkali neutralized by acid, and the eugenol dissolved in sufficient ether. 3°. The ether is distilled off, and the eugenol treated with anhydrous acetic acid. 4°. The aceto-eugenol thus formed is oxidized by a weak and warm solution of potassic permanganate, and the product filtered, rendered slightly alkaline, and concentrated. 5°. It is, lastly, acidulated, and agitated with ether to remove the vanillin.

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* "Chemist and Druggist," 1881, 442.

Natural Order, *Dipterocarpaceæ*.

Camphor Oil.—*Syn.* LIQUID CAMPHOR, OLEUM CAMPHORÆ, OLEUM CAMPHORÆ VOLATILE, L.—Obtained from incisions in the wood of the camphor tree of Borneo and Sumatra (*Dryabalanops aromatica*), in which it exists in cavities in the trunk; also by distillation from the branches of the *Camphora officinarum*, or laurel camphor tree (natural order, *Lauraceæ*). Colourless when rectified. *Prod.* 60 lb. of the crude brown oil yield 40 lb. of pure white oil and 20 lb. of camphor. It rapidly oxidizes in the air. Used to scent soap.

The specific gravity of camphor oil varies somewhat. Mr. PETER MACEWAN[*] finds that of Bornean camphor oil, 0·900; Johore oil, 0·882; Formosa oil, 0·943; Japanese oil, 0·951. According to H. OISHI,[†] the specific gravity of crude Japanese oil is 0·959, and after purification and separation of camphor, 0·895.

The camphor-tree oil is used in Japan as an illuminant, and also for the preparation of carbon for Chinese ink. YOSHIDA[‡] separated a camphor oil five years old into 65 fractions, and these finally into 5 portions, as follows:—

(1°)	Boiling below		145° C.	0·2
(2°)	A hydrocarbon,	B.P.	156° C.	7·0
(3°)	”	”	172°–173° C.	20·0
(4°)	Camphor	”	205° C.	22·8
(5°)	An oxygenated oil	”	212°–213° C.	50·0
				100·0

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[*] "Pharm. Journ." 1885, 1045.

[†] "Chem. News," Dec. 12, 1884.

[‡] "J. Chem. Soc." 1885, 779.

Of these portions (1°) was too small for examination; (2°) was found to be a terebenthene, $C_{10}H_{16}$, identical chemically with, but differing physically from, that yielded by turpentine. Specific gravity at 15° C., 0·8641; and rotatory power, $[\alpha]_j = -76{\cdot}1°$. (3°) Probably *citrene*, having a pleasant lemon odour. Rotatory power, $[\alpha]_j = -68{\cdot}3°$. (5°) The author concludes that the formation of camphor by the ageing of the oil, or by boiling, is due to the presence of this oil, and he names it, provisionally, *camphorogenol*, or camphor hydrate ($C_{10}H_{16}O.OH_2$). It is a colourless, heavy oil; specific gravity, 0·9794 at 20° C.; camphoraceous odour, milder than that of camphor. Soluble in alcohol, ether, and bisulphide of carbon, but insoluble in water. Warmed with dilute nitric acid (1–20) it yields a large quantity of camphor and yellow oil, from which more camphor may be obtained by freezing.

Natural Order, *Geraniaceæ*.

Geranium Oil.—*Syn.* OIL OF GINGER-GRASS, OIL OF SPIKENARD.—The oil of commerce which passes under this name, and which was formerly imported from the East Indies, was not obtained from any species of *Geranium* or *Pelargonium*, but probably from a species of *Andropogon*. Properly, however, the term geranium oil is only applicable to that obtained from some species of *Pelargonium*. The genuine oil from the rose geranium (*Pelargonium roseum*) is prepared in large quantities at La Trappe de Staonelli, not far from the Bay of Sidi Ferruch, in Algiers, where about 40 acres of the plant are in cultivation. "Three harvests are gathered every year, and each yields from 170 to 200 kilograms of oil, or equal to 500 to 600 kilograms per annum. The value of this product never falls below 40 francs the kilogram, the average value being, therefore, from 20,000 to 25,000 francs, or at least £20 per acre."* A finer oil is yielded by the rose geranium grown in France, but it is much dearer. The geranium oils are much used in perfumery and to adulterate otto of roses.

The precious oil called spikenard (OLEUM NARDI) is supposed by some to have been derived from a species of *Andropogon*, but, commercially, geranium oil is also called by this name. BALFOUR, however, states that spikenard was supplied by *Nardostachys Jatamansi* (Nat. Ord. *Valerianaceæ*).

Natural Order, *Magnoliaceæ.*

Star-anise Oil.—*Syn.* BADIAN OIL, OLEUM BADIANI, OLEUM ANISI STELLATI.—From the capsules of *Illicium anisatum*, or star-anise. It continues liquid at 35·5° F. It is used for the same purposes as aniseed oil, and is often mixed with it, or substituted for it. Produce, 2 to 4 per cent.

Natural Order, *Resedaceæ.*

Mignonette Oil.—A thick yellowish-coloured oil, extracted by ether, or "enfleurage," from the flowers of *Reseda odorata*, or mignonette.

Class, CALYCIFLORÆ.

Natural Order, *Amygdalaceæ.*

Almond Oil (Bitter).—*Syn.* ESSENCE OF B. A., OLEUM AMYGDALÆ AMARÆ, O. A. ESSENTIALE, L.—From the ground cake of bitter almonds from which the fixed oil has been expressed. The common plan is to soak the cake (crumbled to fragments) for about twenty-four hours in twice its weight of water, to which one-third or one-fourth of its weight of common salt has been added, and then to submit the whole to distillation, allowing the first half of the water that passes over to deposit its oil, and to run back again into the still. Pale golden yellow; colourless when rectified; tastes and smells strongly nutty, like peach-kernels. It consists of 85 to 90 per cent. of hydride of benzoyl, with a variable quantity of benzoic acid and benzoin, and 8 to 12 per cent. of hydrocyanic acid (4·15 to 6·38 per cent., BRAITHWAITE*). M. FILETI is of opinion that the great difficulty of separating the whole of the hydrogen cyanide, in this oil and in the oil of cherry-laurel, renders it probable that it is present in some form of combination with the benzaldehyde, such as $C_6H_5.CH(OH).CN$. The density varies a little with the age of the oil, and the temperature and rapidity with which it has been distilled. Sp. gr. (recent) 1·0525; (trade crude oil) 1·079 (G. WIPPEL); (old) 1·081 (1·0836, PEREIRA). 1·0524 to 1·0822 (REDWOOD). "Essential oil of almonds, free from adulteration, should have a specific gravity at most of 1·052" (URE). The light oil contains the most hydride of benzoyl, and the heavy oil the most benzoin. *Prod.* From less than ·2 to ·5 per cent.

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* "Pharm. Journ." [3] No. 433.

This oil is generally adulterated with cheaper oils, and in nearly every case with alcohol. When it is pure—1. Mixed with sulphuric acid, it strikes a clear crimson-red colour, without visible decomposition.—2. Mixed with an alcoholic solution of potash, crystals are eliminated.—3. Iodine dissolves only partially and slowly in it, without further visible results.—4. Chromate of potash does not affect it.—5. Nitric acid (specific gravity, 1·42) causes no immediate reaction, and in the course of three or four days crystals of benzoic acid begin to appear; but if only 8 or 10 per cent. of alcohol or rectified spirit is present, a violent effervescence speedily commences, and nitrous fumes are evolved. By using nitric acid (sp. gr. 1·5), the smallest quantity of alcohol may be detected.—6. M. FERRAND states that the presence of nitrobenzol in essence of bitter almonds may be detected as follows:—Heat to ebullition, in a test tube, 3 or 4 c.c. of a 20 per cent. alcoholic solution of potash, together with 10 drops of the suspected essence. If nitrobenzol be present, the mixture takes a red colour; if the essence of bitter almonds be pure, it becomes a pale straw colour.—7. HAGER * has proposed a solution of mercuric nitrate (10 per cent.) as a test of the purity of bitter-almond oil. Four drops of the essential oil are dissolved in 2 c.c. alcohol, and 2 or 3 drops of the nitrate solution added. Pure bitter-almond oil gives no reduction. The greater number of essential oils, however, reduce the nitrate, and their presence in the above is indicated by the formation of a grey precipitate of metallic mercury.

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* "Pharm. Journ." 1886, 659.

This oil does not pre-exist in the almond, but is formed by the action of water on a peculiar crystallizable substance, called amygdalin. It is essentially the hydride of benzoyl, but it always contains a portion of hydrocyanic or prussic acid, to which it owes its very poisonous properties. It is occasionally employed as a substitute for hydrocyanic acid in medicine; but its principal consumption is as a flavouring ingredient and a perfume by cooks, confectioners, liqueurists, and perfumers. For this purpose it is dissolved in rectified spirits. *Dose*, $\frac{1}{4}$ to 1 drop.

An oil closely resembling that from bitter almonds is obtained by distillation from the leaves of the peach and cherry-laurel, the bark of the plum-tree, the bruised kernels of cherries, plums, and peaches, the pips of apples, and from several other vegetable substances that possess a nutty odour and flavour.

A non-poisonous oil of almonds has been introduced. This is simply the ordinary oil of commerce freed from hydrocyanic acid, and is intended to be substituted for the crude, poisonous oil for domestic purposes. Unfortunately, the purified essence does not keep well, and is often converted after a few months into little else than a solution of benzoic acid, almost devoid of the usual odour and flavour of the bitter almond. "No wonder, then, under such circumstances, that the public preferred the preparations they had been accustomed to, which were not so liable to change" (REDWOOD). The following methods have been adopted for this purpose :—

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* "J. Soc. Chem. Ind." 1885, 611.

1. (LIEBIG.) Agitate the crude distilled oil with red oxide of mercury, in slight excess, and, after a few days' contact, rectify the oil from a little fresh oxide of mercury. The product is quite pure, when the process is properly managed. The cyanide of mercury thus formed may be either employed as such, or reconverted into mercury and hydrocyanic acid.

2. (MACKAY.) Commercial oil of almonds, 1 lb.; fresh-slaked lime, q. s. to form a milk-like liquid; afterwards add, of solution of potash, 1½ lb.; water, 3 pints; agitate occasionally for forty-eight hours, then distil over the oil, and rectify it from a fresh mixture of lime and potash.

3. (REDWOOD.) The oil is mixed with an equal quantity of water, and the mixture is digested in a water-bath with red oxide of mercury, and small quantities of fresh-slaked lime and protochloride of iron, with as little access of air as possible; as soon as decomposition of the acid has taken place, the whole is introduced into a copper retort, and submitted to distillation. The product is perfectly free from hydrocyanic acid. The first process is, however, the simplest, cheapest, and best.

The specific gravity of this non-poisonous oil is 1·051 (G. WHIPPELL). That of pure colourless hydride of benzoyl is 1·043; it boils at 356° F., is soluble in 35 parts of water, and in all proportions in alcohol and ether. Exposed to the air, it greedily absorbs oxygen, and becomes converted into a mass of crystallized benzoic acid. The purified oil of almonds does the same, only less rapidly.

Almond Oil (Factitious).—*Syn.* ESSENCE OF MIRBANE, NITROBENZOL.—It is now extensively prepared as a substitute for the oil of almonds obtained by distillation. The following is MANSFIELD'S process:—The apparatus consists of a large glass worm, the upper end of which is divided into two branches, gradually dilating so as to form two funnel-shaped tubes. Into one of these, concentrated nitric acid is poured, and into the other benzol, which need not, for this purpose, be chemically pure. These bodies meet at the point of junction of the two tubes, and the rate of their flow is regulated by any appropriate means. Chemical reaction instantly takes place, and the new compound is cooled by its passage through the worm, which is refrigerated for the purpose. It has then only to be washed with water or a very weak solution of carbonate of soda for the process to be complete. The product has specific gravity 1·209, boils at 415° F., has an intensely sweet taste, and an odour closely resembling, but not actually identical with, that of oil of bitter almonds. Unlike genuine oil of almonds or hydride of benzoyl, it is insoluble in water, and does not distil without suffering partial decomposition. It is chiefly used to scent soaps, and to adulterate the genuine oil. The benzol for this purpose is obtained from coal-tar.

Laurel Oil.—*Syn.* OIL OF SWEET BAY, OLEUM LAURI VOLATILE, O. L. ESSENTIALE, L.—From the berries or leaves of *Laurus nobilis* (Linn.) (Nat. Ord. *Lauraceæ*), or sweet bay-tree. Pale-yellow, clear, aromatic, stimulant, and narcotic. It is a solvent for india-rubber. Specific gravity, ·864 to ·871. Produce, from the leaves, ¾ to 1 per cent.

Cherry-laurel Oil.—*Syn.* OLEUM LAUROCERASI, L.—From the leaves of *Cerasus laurocerasus*, or common laurel. Closely resembles oil of almonds, but is said to be weaker.

It behaves like bitter-almond oil when treated with a 10 per cent. solution of mercuric nitrate (HAGER). Like that substance, it is powerfully poisonous. *Prod.* 100 lb. fresh leaves (undeveloped, June), 10·13 oz.; do. (half-grown, June), 7·2 oz.; do. (full-grown, eight weeks on tree, July), 4·96 oz.; do. (do., three months on tree, Sept.), 7·04 oz.; do. (fifteen months on tree), 2·24 oz. (CHRISTISON).

Natural Order, *Rosaceæ*.

Rose Oil.—*Syn.* OLEUM ROSÆ, ATTAR or OTTO OF ROSES. —(1°) From the petals of *Rosa sempervirens*, or musk-rose, as oil of cloves, observing to keep the water in the worm tub at 85° F., and afterwards subjecting the water in the receiver to refrigeration. Produce, 0·05 to 0·10 per cent.

(2°) From the petals of *Rosa centifolia* or *sempervirens* (damask and musk rose), principally the first, by saturating the water by returning it repeatedly on fresh flowers, and then exposing it to a low temperature. In the East Indies it is obtained by stratifying gingelly seeds in alternate layers with rose petals, for some days, and repeating the arrangement with fresh roses till the seeds are saturated, when the oil is expressed and distilled along with water. In the neighbourhood of Mecca the rose leaves (petals) are macerated in salt and water for two or three days and then distilled, the water being received in separate vessels at different parts of the process. The water is afterwards exposed in earthenware vessels, tied over with linen or muslin, in trenches dug in the earth, and over which moistened straw is thrown, when, in a short time, the otto separates and floats on the surface.

In Bulgaria (SPON) the flowers are not salted, nor subjected to any treatment, before they are introduced into the stills. The stills are made of tinned copper, and are heated by a wood fire. Each charge consists of from 25 to 50 lb.

of roses, not previously deprived of their calyces, with double the volume of spring water. The distillation is carried on for about an hour and a half, and the distillate is a very oily rose-water. The first distillates from each apparatus are mixed and re-distilled by themselves, one-sixth being drawn off: the residue replaces spring water for subsequent operations. The receivers are long-necked bottles, of about 1¼ gallon capacity. Kept for a day or two at a temperature not lower than 60° F. (15·5° C.), most of the oil reaches the surface, and, when skimmed off, is ready for sale. It is stated that 3200 kilo. of roses give 1 kilo. of oil.

The pure oil is colourless, or nearly so, but soon acquires a yellowish colour. Its odour is intense, penetrating, and diffusive, and, in a concentrated state, by no means pleasant, but, when dilute, very agreeable. Its taste is bland and sweetish. When pure, it congeals at 80° F., and does not re-melt until heated to fully 85° F. 1000 parts of alcohol of 0·806 dissolve only 7 parts of otto at 57° F., and only 33 parts at 72° F. Sp. gr., 0·832 at 90° F. *Prod.* 100 lb. of roses yield 2 to 3 dr. oil.

Otto of roses is frequently adulterated with the oils of rhodium, sandal-wood, and geranium, and with camphor; and occasionally also with spermaceti to give the spurious compound the usual crystalline appearance. The following tests are considered reliable:—(1°) Odour and taste. The purity of the odour can be determined only after considerable experience. The taste of the pure otto is bland and sweet. If it is bitter, it contains probably either oil of rhodium or of sandal-wood; if it is pungent, or "bites" the palate, it contains either oil of geranium, or camphor, or both; if it imparts an unctuous sensation, the presence of spermaceti is indicated. (2°) Its congealing point.* A good oil should congeal well in five minutes at 54·5° F. (12·5 C.) —fraudulent additions lower the congealing point. The crystals of rose-stearoptene are light, feathery, shining plates, filling the whole liquid. Almost the only material used for artificially heightening the apparent proportion of stearoptene is said to be spermaceti, which is apt to settle down in a solid cake, and melts at 122° F. (50° C.), whereas stearoptene fuses at 91·4° F. (33° C.). Possibly paraffin wax would more easily escape detection. (3°) Exposed for some hours to the fumes of a small quantity of iodine under a bell-glass in the cold, pure otto remains white, and continues so when exposed to the air; an adulterated sample, on the contrary, becomes yellow, or brown, and afterwards, on exposure to the air, continues to darken in colour, until it becomes of a deep brown, or even perfectly black, according to the quantity of foreign oil present. A single drop may be thus tested. (4°) (GUIBOURT.) One or two drops of the suspected oil are put into a watch-glass; the same number of drops of concentrated sulphuric acid are added, and the two fluids are mixed with a glass rod. All the oils are rendered more or less brown by this proceeding; but otto of roses retains the purity of its odour; oil of geranium acquires a strong and disagreeable smell, which is perfectly characteristic; the odour of oil of rhodium is increased and becomes somewhat unctuous, and, in general, acquires an odour distinctly like that of cubebs. (5°)* Put into a small test tube 1 drop of the otto, and add 4 drops of concentrated sulphuric acid. When the mixture has cooled, add 2 gms. of absolute alcohol and shake well. If the oil is pure, the mixture is slightly opalescent, and, on heating, becomes a yellowish brown, which remains after cooling. But if geranium, pelargonium, or palma rose oil has been mixed with it, the solution becomes cloudy, and, after a little time, an insoluble precipitate separates. Fatty oils, such as almond or sesamé oil, which are sometimes employed to dilute otto, are recognized by leaving a greasy stain on paper after warming. FLÜCKIGER* states that Turkish oil of roses is invariably adulterated, and may contain no *stearoptene*. In a sample made in the laboratory from roses grown in neighbourhood of Leipzig he found 28·8 per cent. of stearoptene.

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* G. W. Lock, "Journ. Soc. Arts," Feb. 11, 1881.

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* "Repartorio di Chimica et Farmacia."

Natural Order, *Leguminosæ*.

Copaiba Oil.—*Syn.* OIL OF CAPIVI, OLEUM COPAIBÆ (B. P., Ph. L. & E.), L.—Yielded by various species of *Copaifera.*—1. (Ph. E.) Balsam of capivi, 1 oz.; water, 1½ pint; distil, returning the water into the still, until oil ceases to pass over.—2. (Wholesale.) From the crude oil which separates during the manufacture of "specific solution of copaiba" and "soluble capivi," by distillation along with a little salt and water.

Colourless when pure; that of commerce has frequently a greenish tinge, derived from the copper utensils; odour, not disagreeable when recent. Sp. gr. ·876 to ·878. *Prod.* 50 to 55 per cent. When adulterated with oil of turpentine, its solubility in rectified spirit is greatly diminished, and the solution is turbid. *Dose,* 10 to 15 drops, on sugar; in the usual cases in which copaiba is ordered, 20 to 60 minims, three times a day (B. P.).

Natural Order, *Amyridaceæ*.

Olibanum Oil.—The resin obtained from *Boswellia floribunda* and *Boswellia thurifera* (*serrata*) contains 4 or 5 per cent. of a volatile oil, which may be separated by distillation with water. It has a yellowish colour, and pleasant, terebinthine odour. Specific gravity, about 0·866.

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* "Arch. Pharm." [3] 23, 185-188.

Myrrh Oil.—*Syn.* OLEUM MYRRHÆ, OLEUM MYRRHÆ ESSENTIALE, L.—Colourless; thin; heavier than water; stimulant; smells strongly of the drug. 100 lb. of myrrh, obtained from *Balsamodendron Myrrha*, or an allied species, yield about 8 oz. of the oil.

Natural Order, *Myrtaceæ.*

Pimento Oil.—*Syn.* OIL OF ALLSPICE, OLEUM PIMENTÆ (B. P., Ph. L., E., and D.)—From the bruised fruit of *Eugenia pimenta*, allspice, or Jamaica pepper. It is of a pale-yellow colour, growing reddish-brown by age; odour, a combination of cloves and cassia; taste, pungent. Its specific gravity is variously stated as 1·021–1·037, and the produce from 3 to nearly 6 per cent. Nitric acid turns the pure oil red, with active effervesence, and the assumption of a rusty-brown colour. It combines with the salifiable bases in a nearly similar manner to oil of cloves. It is much used in perfumery, especially in hair cosmetics.

Eucalyptus Oil.—The *Eucalypti*, of which there are many species furnishing this oil, are natives of Australia, where they are known as "gum-trees," or "stringy-bark" trees. The most interesting and important characteristic of these plants is the power which they undoubtedly possess of correcting, if not of removing, the pestilential exhalations which are regarded as the origin of the fevers that occur in marshy localities. This discovery is due to M. RAMEL, and was made by him in 1856. The leaves contain the essential oil, and from them it may be obtained by aqueous distillation. CLOEZ found the oil chiefly to consist of a substance allied to camphor, which he termed *eucalyptol*. A. FAUST and J. HOMEYER * consider this *eucalyptol* to be a mixture of a terpene and cymol with two other substances, boiling at about 156° C. and 200° C. respectively. KINGZETT, who has recently given great attention to the *eucalypti*, considers the oil[*] to be practically identical in composition with the oil of turpentine derived from pine trees, and with most of the so-called essential oils or perfumes. He is of opinion that all these oils, when subjected to the action of atmospheric oxygen and moisture, produce peroxide of hydrogen and a number of camphoraceous substances having marked antiseptic properties. Any therapeutic power possessed by the tree is to be referred mainly, if not entirely, to the oil. The oil varies in colour, according to the species of the plant from which it is obtained, from light yellow to light blue. It is largely employed as a diluent for the more delicate oils used in perfumery. As an antiseptic dressing for wounds it is claimed[†] for the oil that it possesses not only the advantage over carbolic acid of being non-poisonous, but also of preventing the development of bacteria when it is present in the proportion of 1 in 666 of the dressing, whilst carbolic acid does not do so until the amount reaches 1 in 200. Eucalyptus oil is soluble in oil and pure paraffin, as well as in alcohol. For spray and irrigation, Professor SCHULZ recommends a mixture of the alcoholic solution with water. Dr. SIEGEN[‡] states that a 5 per cent. solution may be employed without drawback. For gauze bandages, he dissolves 3 parts of the oil in 15 of alcohol, and dilutes with 150 parts of water.

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* "Ber. deutsch. Chem. Ges." 1874.

The following list includes the chief varieties of eucalyptus oil:[§]—

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[*] "Chem. News," xl. 183. [†] "Pharm. Journ." [3] xi. 250.

[‡] "Lancet,' September 1880, p. 387.

[§] "Zeitschrift d. Oester. Apoth. Ver." Nos. 24–26.

Species.	Colour and Odour.	Taste.	Sp. gr. at 15° C.	Boiling-point (C.).
Eucalyptus:				
amygdalina.	Pale yellow; odour, like oil of lemon.	Mild, afterwards bitter.	0·881	165°–188°
oleosa.	Pale yellow; odour, mint-like.	Camphor-like.	0·911	161°–177°
sideroxylon.	Very pale yellow; odour, mint-like.	"	0·922	155°–178°
goniocalyx.	Pale yellow; odour, disagreeable.	Very disagreeable.	0·918	152°–175°
globulus.	Very pale yellow; odour, like oil of cajuput.	Cooling, mint-like.	0·917	149°–177°
corymbosa.	Colourless; odour, faintly lemon and rose-like.	Feebly bitter, slightly camphoraceous.	0·881	...
obliqua.	Yellowish-red; odour, mild.	Bitter.	0·899	171°–195°
fissilis.	Pale yellowish red; odour, mild.	...	0·903	177°–196°
odorata.	Pale yellowish green; odour, aromatic.	...	0·899–0·922	157°–199°
longifolia..	Thicker than preceding oils; odour, strongly camphoraceous.	Cooling and aromatic.	0·940	194°–215°
rostrata.	Pale yellow to amber; odour as last.	"	0·918	131°–181°
viminalis.	Pale greenish yellow; odour unpleasant.	...	0·921	159°–182°

Eucalyptus oil has been placed in the new Pharmacopœia (1885), where it is thus described :—"The oil distilled from the fresh leaves of *Eucalyptus globulus*, Labill.; BENTLEY and TRIM. Med. Pl. vol. ii. pl. 109; *Eucalyptus amygdalina*, Labill.; and probably other species of eucalyptus. *Characters and tests.*—Colourless or pale straw coloured, becoming darker and thicker by exposure. It has an aromatic odour, and a spicy and pungent flavour, leaving a sensation of coldness in the mouth. It is neutral to test-paper. Specific gravity, about 0·900; soluble in about an equal weight of alcohol." With regard to tests, Mr. P. MACEWAN* says that, as regards acidity, it develops with age, and at the same time the oil improves in the ordinary sense of the term. The alcohol used as a test of solubility therein should be rectified spirit, not *absolute* alcohol; oils above specific gravity 0·880 should be soluble in their own volume, and those of less specific gravity should require not more than six volumes. Presence of turpentine reduces the solubility. Mr. MACEWAN considers that the best test for the detection of turpentine is LANGBECK's salicylic acid test.* An oil above 0·880 should dissolve not less than a tenth of its weight of salicylic acid, and lighter oils not less than a sixteenth.

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* Pharmaceutical Conference, 1885.

Natural Order, *Umbelliferæ.*

Angelica Oil.—The root of *Angelica archangelica* (*Angelica officinalis*), dried, and submitted to aqueous distillation, yields about 1 per cent. of oil. This oil, and also that from the seeds, have recently been studied by L. NAUDIN,† who finds the sp. gr. of the former to be 0·875 at 0° C. and that of the fruit to be 0·872.

Aniseed Oil.—*Syn.* OLEUM ANISI (Ph. L., E., & D.), O. ESSENTIALE ANISI, L.—From the fruit (seeds) of *Pimpinella anisum*, or anise. Nearly colourless. It is very frequently adulterated with one or other of the cheaper oils, in which case spermaceti or camphor is added to it to make it "candy."

When pure, it congeals into a solid crystalline mass on being cooled to 50° F., and does not melt again until heated to about 63°. Treated with iodine, it quickly congeals into a solid hard mass, with a perceptible increase of temperature, and the development of orange-coloured and grey fumes. Sulphuric acid, with heat, turns it of a rich purple-red colour, and the compound soon afterwards becomes inspissated and hard (resinified). In alcohol of ·806 it is soluble in all proportions, but rectified spirit (·838) dissolves only 42 per cent. of this oil. Sp. gr. (recent) ·9768; (one year old) ·9853 to ·9855; (old) ·9856 to ·9900. The foreign oil is generally the heaviest.

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* "Pharm. Journ." [3] xv. 309.

† "Comptes Rendus," xciii. 1146, and "Bull. de la Soc. Chim." xxxix. 406-409.

Oil of aniseed is carminative and pectoral; and both itself and preparations have long been in favour with the masses in coughs, colds, &c. In preparing it, care must be taken that the temperature of the water in the receiver and refrigerator does not fall lower than about 68° F. *Prod.* (from the dried fruit of commerce) 2 per cent. (nearly).

Caraway Oil.—*Syn.* OLEUM CARUI (B. P., Ph. L., E., & D.), O. C. ESSENTIALE, L.—From the fruit of *Carum carui* (caraway seeds). Nearly colourless; aromatic; carminative. Sp. gr. ·940; (old) ·946 to ·950. *Prod.* 5 per cent. (nearly). It is frequently adulterated with oil of cumin. Added to purgative medicines to prevent griping.

Also used as a scent for soaps. GLADSTONE has shown that the *carvol* obtained from caraway oil agrees in its principal physical properties with the carvol from dill oil. FLÜCKIGER found that the carvol from German mint oil (*Mentha crispa*) differed from the carvol from the other two sources in being strongly lævo-rotatory—the others being dextro-rotatory. These results have been confirmed by BEYER.*

Celery-seed Oil.—*Syn.* OLEUM APII, L.—From the fruit (seed) of *Apium graveolens.* Diuretic; stimulant. It is a colourless or pale-yellow oil, of penetrating odour and sweetish taste. Sp. gr. about 0·881; readily soluble in alcohol. *Prod.* $\frac{3}{4}$ to nearly 1 per cent.

Dill Oil.—*Syn.* OLEUM ANETHI (Ph. L. & E.), L.—From the bruised fruit (seed) of *Anethum graveolens.* Pale-yellow; odour, that of the fruit; taste, hot and pungent; carminative. Sp. gr. about ·882. The oil is skimmed off from the distillate, and the residue forms commercial dill water. *Prod.* about 4 per cent.

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* "Archiv. der Pharm." [3] xxi. 283-288; "Journ. Chem. Soc." 1884, 331.

Coriander Oil.—*Syn.* OLEUM CORIANDRI.—By aqueous distillation of the bruised seeds of *Coriandrum sativum.* Yellowish; aromatic; carminative. Sp. gr. about 0·860. Produce of the dried fruit, 5 to 6 per cent. It is largely used in the preparation of liqueurs. Often adulterated with rectified oil of orange-peel. According to LEONHARDI,* this admixture is indicated by the turbidity produced in the suspected sample when mixed with an equal bulk of 90 per cent. alcohol.

Cumin Oil.—*Syn.* OLEUM CUMINI, O. CYMINI.—From the fresh fruit (seed) of *Cuminum cyminum,* or cumin. Pale-yellow; smells and tastes strongly of the seeds. Sp. gr. about 0·975. *Prod.* 2 to 3 per cent.

Fennel Oil.—*Syn.* OLEUM FŒNICULI (Ph. L.), O. F. OFFICINALIS (Ph. E. & D.), O. F. DULCIS, L.—From the fruit or seed of *Fœniculum dulce,* or sweet fennel (Ph. L.). Colourless; odour, that of the plant; tastes hot and sweetish; congeals at 50° F.; carminative and stomachic. It consists of two oils, the one solid and identical with that of oil of aniseed. When treated with nitric acid, it affords benzoin. Sp. gr. ·997. *Prod.* dried fruit (of commerce), 3 to 3·5 per cent. The flowering herb yields ·35 per cent. of a similar oil.

The oil of fennel of the shops is the product of the fruit of *Fœniculum vulgare,* or common, wild, or bitter fennel. It closely resembles that of sweet fennel, but is scarcely so agreeable either in taste or smell. It is chiefly used to scent soaps. The stearoptene of oil of fennel is said by LEONHARDI to be largely imported from Russia, and is used for adulterating oil of anise.

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* "Arch. Pharm." [3] xii. 490–493.

Galbanum Oil.—*Syn.* OLEUM GALBANI (Ph. Bor.), L.—From galbanum, 2 lb.; water, 16 fl. oz.; distilled together. Yellow; resembles oil of assafœtida, but milder. Sp. gr. about 0·904. From either *Opoidia galbanifera* or *Galbanum officinale.*

Lovage Oil.—*Syn.* OLEUM LEVISTICI.—From the leaves and fruit of *Levisticum officinale*, or lovage. Pale-yellow, aromatic, carminative. *Prod.* fresh herb 0·1 to 0·15 per cent.

Natural Order, *Compositæ.*

Chamomile Oil.—*Syn.* OIL OF ROMAN CHAMOMILE, OLEUM ANTHEMIDIS (Ph. L., E., & D.), O. CHAMÆMELI, O. C. FLORUM, O. ESSENTIALE EX FLORIBUS C., L.—From the flowers of *Anthemis nobilis.* In the Ph. L., English oil of chamomile (ANTHEMIDIS OLEUM ANGLICUM) is ordered. Blue; turns yellow and brown by exposure and age; odour characteristic. Sp. gr., English (from the flowers), ·9083; foreign, ·9289. *Prod.* fresh flowers, ·1 per cent. (barely); recently dried (finest commercial), 5 per cent.; average of 6 dried samples, ·25 per cent. (nearly). If much water is employed, even the above small quantities of oil will not be obtained.

Oil of chamomile is reputed antispasmodic, tonic, and stomachic. 1 to 3 drops on a lump of sugar, taken just before retiring to rest, is an excellent preventive of nightmare, and will frequently induce quiet sleep where more active substances have failed. Unfortunately, the oil of the shops is generally either adulterated or old, and commonly both, in which case the oil acts as an irritant. A common plan is to mix it with old oil of lemons—a fraud which may be detected by the lessened density of the oil, and by its diminished solubility in rectified spirit.

Mugwort Oil.—A butter-like, crystallizing oil is obtained by aqueous distillation from the root of *Artemisia vulgaris*. Colour, pale greenish yellow; odour, penetrating; flavour, bitter and nauseous. Readily soluble in alcohol. The leaves of *Artemisia dracunculus* yield on distillation an essential oil known as *Tarragon* oil. Sp. gr. about 0·935.

Wormwood Oil.—*Syn.* OLEUM ABSINTHII, L.—From the herbaceous portion of *Artemisia absinthium*, or common wormwood; green or brownish-green; odorous; acrid; bitter; stomachic. Sp. gr. ·9703 (BRISSON); ·9720 (PEREIRA); ·9725 (BRANDE). *Prod.* fresh herb (picked), ¼ to ⅓ per cent.; dry herb (a year old), ½ per cent. (fully); do. (recent), ¾ to 1 per cent. (fully).

That of the shops is nearly always either adulterated or partly spoilt by age; hence the discrepancies in the densities given for this oil by different authorities. A specimen of this oil distilled by Mr. COOLEY from the green plant had the specific gravity ·9712; but after being kept for twelve months, it had increased to ·9718. Nitric acid of 1·25 colours the pure oil first green, then blue, and, lastly, brown. The positive character of these reactions is in direct proportion to the purity and freshness of the sample.

Class, COROLLIFLORÆ.

Natural Order, *Jasminaceæ.*

Jasmin Oil.—*Syn.* OIL OF JESSAMINE, OLEUM JASMINI, O. J. VOLATILE.—From the flowers of *Jasminum grandiflorum* and *J. fragrans* carefully picked. They are placed in alternate layers with cotton wadding imbued with olive oil, in any suitable vessel, and renewing the flowers till the mass becomes strongly odorous, and then distilling the wadding along with a little water. The volatile oils of hyacinths, jonquil, violets, and other delicate flowers, are obtained in the same way. Much used in perfumery.

Natural Order, *Labiatæ*.

Hyssop Oil.—*Syn.* OLEUM HYSSOPI.—From the flowering herb *Hyssopus officinalis*. Colourless; camphor-like flavour. Specific gravity, 0·8–·98. Aromatic; stimulant. *Prod.* 0·25 to 0·33 per cent.

Lavender Oil.—*Syn.* ESSENCE OF L., LAVANDULÆ OLEUM (B. P.), OLEUM LAVANDULÆ (Ph. L.), O. L. VERÆ (Ph. E. & D.), O. L. SPICÆ, O. L. ESSENTIALE, O. L. FLORUM, L.—The oil (OLEUM LAVANDULÆ ANGLICUM) distilled from the flowers of "*Lavandula vera*" (Ph. L.). Very pale lemon-yellow; highly fragrant; taste, warm, and not disagreeable; carminative, antispasmodic, and stimulant. Specific gravity, ·877 to ·905. According to BRANDE, the specific gravity of the oil obtained from the flowers only is ·8960; that from the whole plant, ·9206. The lightest is esteemed the best. *Prod.* flowers, 1½ to 2 per cent. (nearly). The whole of the flowering herb is commonly distilled. According to RAYBAUD, the herb, after flowering (Sept.), yields the most oil.

Alcohol is the substance commonly used to adulterate this oil; but, occasionally, oil of bergamot is used for the same purpose. If the density is below ·87, there is reason to suspect adulteration. When pure—1. Sulphuric acid turns it reddish-brown, and the reaction is accompanied by strong inspissation.—2. It fulminates quickly and violently with iodine, and the thick syrupy residue possesses a pungent, acid, balsamic odour. The oils of the other labiate plants fulminate much less powerfully with iodine. The presence of alcohol weakens, but does not destroy, the action of this test, unless it is added in an equal volume, when only a lively effervescence and a disengagement of orange-coloured vapours are produced by the iodine, without fulmination.—3. Santaline is nearly insoluble in pure oil of lavender, and exerts no marked action on it, but is freely soluble in oil of lavender adulterated with alcohol or rectified spirit.

English oil of lavender possesses the purest fragrance; and of this, the variety known as "Mitcham oil of lavender," from the place of its preparation, is esteemed the best. The foreign oil of lavender is inferior. This last is improved by rectification. *See* SPIKE OIL.

Spike Oil (True).—*Syn.* FOREIGN OIL OF LAVENDER, OLEUM SPICÆ, O. S. VERUM, O. STÆCHADIS, O. LAVANDULÆ S. (L.), HUILE D'ASPIC, Fr. Chiefly from *Lavandula spica* and *L. stœchas*, or French and Alpine lavenders. It differs from English oil of lavender by its darker green colour and inferior odour. From France. Used by artists to mix their colours in and to make varnishes. Oil of turpentine scented with lavender is commonly sold for it. *Prod.* from *L. spica* (fresh), ¾ to 1½ per cent.; *L. stœchas* (dried), ¾ to 1 per cent. (fully).

Marjoram Oil.—*Syn.* OIL OF SWEET M., OLEUM MARJORANÆ, O. ORIGANI M. (Ph. E.), L.—From the fresh flowering herb of *Origanum marjorana*, or sweet or knotted marjoram. Pale-yellow; odorous; tonic; stimulant. Specific gravity, ·925 (·940, BAUMÉ). *Prod.* ·33 to ·35 per cent. *See* ORIGANUM OIL.

Origanum Oil.—*Syn.* OLEUM ORIGANI, O. O. ESSENTIALE, L.—From the flowering herb of *Origanum vulgare*, or common or winter marjoram. Pale-yellow colour; fragrant; acrid, pungent, and rubefacient. Specific gravity, ·927 (·940, BAUMÉ). *Prod.* ·5 to ·75 per cent. The dark-coloured oil of origanum of the shops is obtained from *Thymus vulgare.* The oil of origanum (Ph. E.) is oil of *Origanum marjorana.* *See* MARJORAM OIL.

Peppermint Oil.—*Syn.* OLEUM MENTHÆ PIPERITÆ (B. P., Ph. L., E., & D.), O. ESSENTIALÆ M. PIPERITIDIS, L. —From the fresh flowering herb of *Mentha piperita*, or garden peppermint. Nearly colourless, or at most a very pale greenish yellow; powerfully odorous; tastes pungent, at the same time imparting a sensation of coldness to the tongue and palate. Boils at 365° F. Specific gravity, ·902 to ·905. *Prod.* fresh flowering herb, ·25 to ·4 per cent.; dried ditto, 1 to 1·25 per cent. (fully). In a warm dry season, 5 lb. of the fresh flowering herb yield 1 oz. of oil; in a wet and unfavourable one, 11 lb. yield barely the same quantity.

The oil of commerce usually contains fully a third part of rectified spirit, and is also frequently adulterated with the oils of rosemary, spearmint, and turpentine. When pure—1. It is soluble in its own weight of rectified spirit. —2. Mixed with one-fourth its volume of nitric acid, a rich purple-red colour is developed. FLÜCKIGER states that it gives a blue-green colour with nitric acid of specific gravity 1·2. SCHACK says this reaction can be well obtained also by slightly warming 1 c.c. glacial acetic acid with 1 drop of peppermint oil.—3. Chromate of potash, in solution, turns it of a deep reddish-brown colour, and converts it into a soft coagulum, which assumes a flaky form when divided with a glass rod, whilst the solution of the salt loses its yellow colour or becomes greenish-yellow.—4. With iodine it forms a homogeneous mass, without fulmination. If it explodes with iodine, it contains turpentine. The yellowish, resinous oil, sold under the name of "American" or "crude oil of peppermint," consists chiefly of oil of turpentine, and on evaporation leaves a residuum of pine resin.

English oil of peppermint is the best—a fact clearly shown by its price in the market being so greatly above that of the imported oil. The oil distilled at Mitcham, in Surrey (Mitcham oil of peppermint), is the most esteemed. It has usually a very pale greenish colour, which is often imitated by steeping a leaf or two of green mint or parsley in the oil. Old dark-coloured oils are commonly bleached by exposure to the light, to the destruction of a portion of their other properties. Peppermint is also cultivated in England at Wisbeach, in Cambridgeshire, Market Deeping, in Lincolnshire, and Hitchin, in Herts.

Of late years an essential oil of peppermint manufactured by Messrs. HOTCHKISS, of New York, has come into considerable demand. This, which is said to be a very pure article, differs from the other peppermint oils in becoming thick when first mixed with spirit of wine. After a short time, however, the mixture clears and becomes perfectly bright.

According to a valuable report upon these articles in the Paris Exhibition of 1878, more particularly interesting to the pharmacist, the chemical manufacturer, the perfumer, &c., which appeared in the "Pharmaceutical Journal," the above statement is open to question. Of late years it seems that a considerable industry has sprung up at Arzin, in the Department du Nord, in France, where large quantities of labiate plants are cultivated, and subsequently submitted to distillation. An acre of land generally yields every year from 3 to 4 tons of the peppermint plant; and from 500 parts of this, 1 part of essential oil is usually obtained, which, it is alleged by M. HANART, the distiller of the oil in question, after being carefully bottled and kept for some years, successfully rivals the English oil both in quality and price.

Oil of peppermint is stimulant, antispasmodic, and carminative, and has always been a favourite remedy in flatulence, nausea, vomiting, loss of appetite, cramp of the stomach, colic, griping pains, diarrhœa, the early stage of cholera, &c. *Dose,* 1 to 3 drops, on sugar.

Peppermint oil is one of the few essential oils which are produced on a large scale ("Pharmacographia"). The oils of turpentine, lemon, bergamot, grass oil, and oil of caraway are the only ones which are sent to market in much more considerable quantities.

The value of the oil is said to depend upon the solid compound which it contains, termed *menthol,* $C_{10}H_{19}OH$. Menthol is the "camphor" of peppermint oil.

Patchouly Oil.—From the leaves of *Pogostemon patchouly,* a native of Singapore. The dried, selected leaves are distilled with steam. 16 oz. of leaves yield about ¼ oz. of oil. In specific gravity it varies from about 0·955 to 0·960. Much used in perfumery.

Rosemary Oil.—*Syn.* ROSMARINI OLEUM (B. P.), OLEUM ANTHOS, O. RORISMARINI, O. ROSMARINI (Ph. L., E., & D.), O. RORISMARINI ESSENTIALÆ, L.—From the flowering tops of *Rosmarinus officinalis.* In the Ph. L., English oil of rosemary (O. ROSMARINI ANGLICUM) is ordered, as it is superior to that from abroad. Colourless; strongly fragrant, but scarcely agreeable unless compounded; carminative and stimulant. Boils at 365° F. Specific gravity, ·910; recent, ·897; rectified, ·8887. *Prod.* ¾ to 1 per cent. (nearly).

It is frequently adulterated with oil of turpentine. When pure, it dissolves in all proportions in spirit of ·830 By age it deposits a crystalline stearoptene, and acquires a terebinthinate odour. It is chiefly used as a stimulant in liniments, hair oil, pomatums, &c.

Spearmint Oil.—*Syn.* ENGLISH OIL OF SPEARMINT (B. P.), OIL OF MINT, OIL OF GREEN M., MENTHÆ VIRIDIS OLEUM (B. P.), OLEUM MENTHÆ VIRIDIS (Ph. L., E., & D.), O. M. SATIVÆ, O. ESSENTIALE MENTHÆ S., L.—From the fresh flowering herb of *Mentha viridis* (Linn.), or garden or spearmint. Pale-yellow; reddened by age; odour and general properties resemble those of oil of peppermint, but it is less grateful. It boils at 320° F. Specific gravity, ·915 (·9394, BRANDE). *Prod.* ·2 to ·25 per cent. Its common adulterants are alcohol and oil of turpentine.

Thyme Oil.—*Syn.* OLEUM THYMI, OIL OF ORIGANUM, OLEUM ORIGANI (of the shops).—From the flowering herb of *Thymus vulgaris* (Linn.), or garden thyme. Nearly colourless; the imported oil has a reddish colour, which it loses by rectification; very fragrant; acrid; hot tasted, stimulant, and rubefacient; boils at 354° F. Specific gravity, ·867 to ·875. *Prod.* ·5 to ·75 per cent.

This is the dark-coloured "oil of origanum" of the shops. It is frequently adulterated with oil of turpentine. It is occasionally used in toothache and in stimulating liniments, but its chief consumption is in perfumery, more particularly for hair oils, pomatums, and hair washes, as it is reputed to make the hair grow and to prevent baldness.

Pennyroyal Oil.—*Syn.* OLEUM PULEGII (Ph. L.), O. MENTHÆ P. (B. P., Ph. E. & D.), O. P. ESSENTIALE, L.—From the flowering herb of *Mentha pulegium*, or the common pennyroyal of our gardens. Pale-yellow, growing reddish-yellow by age and exposure; antispasmodic, carminative, and emmenagogue. Boils at 395° F. Specific gravity, ·925 to ·931. *Prod.* ¾ to 1 per cent.

Natural Order, *Ericaceæ.*

Wintergreen Oil. — *Syn.* PARTRIDGE - BERRY OIL, METHYLO-SALICYLIC ETHER, SALICYLATE OF OXIDE OF METHYL, OLEUM GAULTHERIÆ (Ph. U.S.), L.—From the leaves or the whole plant of *Gaultheria procumbens*, a herb common in North America, and otherwise known by the names—boxberry, chequer-berry, partridge-berry, mountain tea, wintergreen, &c. Pale-yellow, growing brown by exposure and age; aromatic; sweet; highly pungent; when diluted, agreeably fragrant; mixed with a dilute solution of potash, it solidifies to a crystalline mass (salicylate of methyl and potash), from which the oil may be again separated by the addition of an acid. It is the heaviest of all the essential oils. Specific gravity, 1·173. Boils at 412°, and, when purified, at 435° F. It is adulterated often with camphor oil, which would lower its specific gravity and thus indicate the sophistication. A rough test, according to Mr. P. MacEwan, is to gently agitate a few drops of the oil with water. If pure, it would wholly subside in a few seconds; but if it contains camphor oil, several minutes would elapse before it subsides. The pure oil gives no colour with nitric acid, but oil adulterated with camphor oil becomes red when similarly treated. Oil of wintergreen dissolved in rectified spirit is used in the United States of America as an antispasmodic, carminative, diuretic, emmenagogue, and stimulant; chiefly as an adjunct to mixtures, &c.; and also with the view of increasing the flow of milk during lactation. It is likewise extensively used in perfumery, and is an object of great interest to the chemist on account of its peculiar constitution and reaction.

Natural Order, *Rutaceæ*.

Buchu Oil.—*Syn.* OLEUM BAROSMÆ, O. DIOSMÆ, L.—From the leaves of *Diosma crenata*. Yellow; lighter than water; smells of the leaves.

Rue Oil.—*Syn.* RUTÆ OLEUM (B. P.), OLEUM RUTÆ (Ph. L. & E.), L.—The "oil distilled from the fresh herb of *Ruta gravolens*" (B. P.), or common rue. Pale-yellow, turning brown by age, and depositing a brownish, resinous sediment; congeals at about 40° F.; acrid, bitter; odour that of the plant; stimulant, antispasmodic, and emmenagogue. Specific gravity, ·909 to ·911. *Prod.* ¼ to 1 per cent. (nearly). According to Raybaud, the recent dried seeds yield fully four times as much oil as the flowering herb.

Nearly always adulterated. When pure—1. It forms a clear solution with rectified spirit.—2. It does not form a camphor with gaseous hydrochloric acid.—3. Iodine dissolves in it slowly, without any apparent reaction beyond a darkening and a slight increase of viscidity.—4. It is unaffected by a solution of chromate of potash.—5. Nitric acid very slowly changes it into a greenish-yellow liquid balsam.—6. If it turns reddish-brown with solution of potash and still darker with sulphuric acid, or if it fulminates with iodine, it is adulterated with the oil of some labiate plant.—7. It is more soluble in both rectified spirit and water than any of the oils used to adulterate it.

Class, Monochlamydeæ.

Natural Order, *Betulaceæ*.

Birch Oil.—*Syn.* Oleum betulæ, L.—From the inner bark of the birch, by heating it in an earthen pot with a hole in the bottom, to allow the oil to flow through into another jar sunk in the ground and luted to it. Thick, balsamic, fragrant. Used chiefly to dress Russia leather.

Natural Order, *Chenopodiaceæ*.

Goosefoot Oil.—(Ph. U.S.) *Syn.* Oleum chenopodii. —Distilled from the seeds of *Chenopodium anthelminticum*. *Dose*, from 4 to 8 drops, with treacle or milk, for three nights in succession, for children. For adult, ½ dr. Vermifuge.

Natural Order, *Coniferæ*.

Amber Oil.—*Syn.* Oleum succini.—Amber is a well-known resinous substance, which is considered to be a produce of many fossil *Coniferæ* of the Eocene epoch, such as *Peuce succinifera.* It occurs in East Prussia in great quantity, and it is said that many pieces of fossil wood occur there which, when moderately heated, give out a decided smell of amber (BALFOUR). The oil of amber is obtained when coarse pieces of amber are distilled in iron retorts in the preparation of succinic acid from amber, in the proportion of about 6 oz. from 6 lb. The crude oil is thick, and of a brownish-green colour. It may be rectified with about 6 volumes of water by a gentle heat. It then forms "rectified oil of amber," and is of a pale-yellow colour. Odour, bituminous; flavour, acrid. Specific gravity, about 0·922 at 60° F. (15·5° C.). It is antispasmodic, rubefacient, and stimulant. *Dose,* 5 to 12 drops, made into an emulsion with mucilage; in hysteria, epilepsy, and convulsive affections. Externally, as a friction, either alone or combined with laudanum or sweet oil, in rheumatism, tic-douloureux, hooping-cough, &c. Also used in perfumery.

Cedar Oil.—*Syn.* CEDAR-WOOD OIL.—From the wood of a species of *Cedrus,* or from the shavings produced in manufacture of pencils from the American cedar, *Juniperus virginiana.* It consists of two hydrocarbons, one a volatile liquid (*cedrene*) and the other a solid, crystalline compound containing oxygen. Cedar oil is a soft, white, crystalline body, with pleasant aromatic odour. It is used for scenting soaps. Sometimes it is spoken of as "North American savin." *Prod.* 0·2 to ·25 per cent.

Juniper Oil.—*Syn.* JUNIPERI OLEUM (B. P.), OLEUM JUNIPERI (Ph. L., E., & D.), O. E. BACCIS J., O. ESSENTIALE E. B. J., L.—From either the wood, tops, or berries, preferably the last. The berries should be chosen fully grown, but still slightly green, and should be bruised before being placed in the still. In the Ph. L., English oil of juniper (O. JUNIPERI ANGLICUM) is ordered. Colourless, or very pale greenish-yellow; odour and taste, sweet and terebinthinate; rather viscid; soluble in rectified spirit; rendered opaque and resinous by exposure and age. It is reputed carminative and diaphoretic, and possesses powerful diuretic properties. Specific gravity, ·911 (English, ·8688; foreign, ·8834, BRANDE). *Prod.* green berries, ·25 per cent.; ripe ditto (one year old), ¾ to 1 per cent. (fully).

It is frequently adulterated with oil of turpentine—a fraud readily discovered by the lessened density, viscidity, and solubility in rectified spirit, of the oil.

Oil of juniper consists of two oils—one, white and more volatile, specific gravity, ·8393; the other, dark-coloured and less volatile, specific gravity, ·8784; together with some resin left in the retort.

Savine Oil.—*Syn.* OLEUM SABINÆ (B. P.), OLEUM JUNIPERI SABINÆ, O. SABINÆ (Ph. E. & D.), L.—From the fresh tops or leaves of *Juniperus sabina*, or common savin. Pale-yellow; limpid; acrid, pungent, and stimulant. It possesses the general properties of the plant in a highly exalted degree. Specific gravity, ·915. *Prod.* fresh herb, 1·25 to 1·5 per cent.; dried ditto (recent), 2½ to 3 per cent. *Dose*, 2 to 6 drops; as an anthelmintic, diaphoretic, and emmenagogue. Its use must be carefully avoided during pregnancy or disease of the abdominal viscera.

It is less frequently adulterated than the other volatile oils. Its high specific gravity and free solubility in rectified spirit offer the means of detecting the presence of either oil of turpentine or alcohol, the substances occasionally added to it. A mixture of equal parts of oil of savin and oil of vitriol, by distillation from milk of lime, furnishes an oil apparently identical with oil of thyme (WINCKLER).

Turpentine Oil.—*Syn.* SPIRIT OF T., ESSENCE OF T., TURPS, CAMPHENE, CAMPHINE, TEREBINTHINÆ OLEUM (B. P.), SPIRITUS TEREBINTHINÆ, ESSENTIA T., OLEUM TEREBINTHINÆ

(Ph. L. & D.), O. T. PURIFICATUM (Ph. E.), L.—The oil of turpentine of commerce is obtained by distilling strained American turpentine along with water. The residuum in the still is "resin," "rosin," or colophony. The product in oil varies from 14 to 16 per cent. The Colleges order it to be rectified before being employed for medicinal purposes. This is effected by redistilling it along with 3 or 4 times its volume of water, observing not to draw over quite the whole. The portion remaining in the retort (balsam of turpentine) is viscid and resinous. A better plan is to well agitate it with an equal measure of solution of potash or milk of lime before rectifying it. This is the plan adopted for the camphine used for lamps. By agitating crude oil of turpentine with about 5 per cent. of sulphuric acid, diluted with twice its weight of water, and, after repose and decantation, rectifying it from 5 or 6 times its volume of the strongest lime water, a very pure and nearly scentless oil may be obtained. Dr. NIMMO recommends oil of turpentine to be purified by agitation with one-eighth part of rectified spirit, after repose to decant the spirit, and to repeat the process three or four times. The product retains, however, fully one-fifth part of spirit in solution, and hence this method is objectionable, except for medicinal purposes, for which, according to Dr. GARROD, it is better than the oil purified by rectification. The sweet spirits of turpentine (SPIRITUS TEREBINTHINÆ DULCIS) vended of late years in the shops is simply the common oil which has been agitated with, and rectified from, somewhat dilute sulphuric acid.

BERTHELOT'S researches have shown that the volatile oil obtained by distillation has the composition $C_{10}H_{16}$, and varies in chemical and physical properties according to its source. That from *Pinus maritima* (French) is lævo-rotatory. That from *Pinus australis* (English) is dextro-rotatory.

Turpentines from the following sources are used :—

(1°) French turpentine oil: from the French or Bordeaux turpentine of *Pinus maritima.*

(2°) English turpentine oil: from the turpentine collected in the United States from *Pinus australis* and *P. tæda.*

(3°) German turpentine oil: from *Pinus sylvestris, P. nigra,* and *P. rotundata.*

(4°) Venetian turpentine oil: from Venice turpentine, the produce of *Larix europæa.*

(5°) Templin, or pine-cone oil: obtained from the cones of *Pinus pumilio,* and in some parts of Switzerland from those of *Abies pectinata.*

Dr. ARMSTRONG has recently published some investigations on turpentine.[*] He points out that of the hydrocarbons of the formula $C_{10}H_{16}$, of which commercial turpentines mainly consist, three distinct classes may be distinguished—viz., *terpenes, citrenes,* and *sylvestrenes.* Under the first term are included those varieties which boil at about 156° C.; and under the second, those which boil about 176° to 178° C., and which occur as the chief constituents of the oils derived from various species of *Citrus. Sylvestrene* has been shown by TILDEN[†] to exist in Russian turpentine, together with an isomeride possessing the character of American turpentine.

Dr. ARMSTRONG finds the optical activity of French turpentine, operating with a 200 mm. tube, to be on the average $a_D = -60°$ to $-61°$, and that of American turpentine to vary from $a_D = 19°$ to $46°$.

The specific rotatory power of *sylvestrene,* according to TILDEN, is $a_D = 19·6°$, and of the hydrocarbon associated with it $a_D = 36·3°$.

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[*] "J. Soc. Chem. Ind." 1882, 478.

[†] "Chem. Soc. Trans." 1878, 80.

Armstrong thinks it probable that American turpentine is also a mixture of isomeric hydrocarbons, and that the low dextro-rotatory power of some samples of it may be due to the presence of a lævo-rotatory terpene. In this way the difference in optical properties of products from different localities might be explained.

Pure oil of turpentine is colourless; limpid; very mobile; neutral to test-paper; has an odour neither powerful nor disagreeable when recently prepared, but becoming so by exposure to the air; dissolves one-fifth part of alcohol of ·830; is soluble in 6 parts of ether and in 7½ parts of rectified spirit; hot, strong alcohol dissolves it freely, but the greater part separates in globules as the liquid cools. Oil of vitriol chars it, and strong nitric acid attacks it violently, even with flame. It congeals at 14°, and boils at 312° F. Sp. gr. ·867; that of the oil of the shops varies from ·872 to ·878. It possesses a very high refractive power. At 72° it absorbs 163 times its volume of hydrochloric-acid gas (if kept cool), and in twenty-four hours from 26 to 47 per cent. of crystals (Kind's camphor) separate. These have a camphoraceous odour, and, after being washed with water, and sublimed along with some dry chalk, lime, or charcoal, assume the form of a white, translucent, flexible, crystalline mass, which is volatile, soluble in alcohol, and possesses a considerable resemblance to camphor. A nearly similar substance is produced by the action of oxygen gas on oil of turpentine.

Oil of turpentine is extensively used in the manufacture of varnishes and paints. Under the name of "camphine" it is occasionally employed for burning in lamps. For the last purpose it must be newly rectified and preserved from the air. By exposure, it rapidly absorbs oxygen, resin is formed, its density increases, and it gives a dull fuliginous flame. In medicine it is employed as a diaphoretic, stimulant, vermifuge, &c. *Dose*, 6 to 30 or 40 drops; in rheumatism, hemicrania, &c., 1 fl. dr. every four hours, in combination with bark or capsicum; in tapeworm, 3 fl. dr. to 1 fl. oz., either alone or combined with a little syrup of orange peel, every eight hours, until the worm is expelled. The common symptoms of large doses of this oil are dizziness and a species of temporary intoxication, and occasionally nausea and sickness, which subside after two or three alvine evacuations, leaving no other effect, when the oil is pure, than a certain degree of languor for a few hours. In tapeworm a little castor oil may be advantageously combined with the second and subsequent doses. Oil of turpentine imparts a violet odour to the urine. To prevent loss by evaporation and resinification, this oil should be kept in tin cans or glass bottles. For store vessels, closely covered tin cisterns are the best. To *prevent accidents* it is proper to remind the operator of the extremely penetrating and inflammable nature of the vapour of this oil, even in the cold. During the process of its distillation, unless the greatest precautions are taken, an explosion is very possible.

The presence of petroleum oil, according to ARMSTRONG,* may be readily detected, if mixed with turpentine, by steam distilling. By "petroleum oil" is understood that portion of crude petroleum which is not volatilized by steam from water, boiling at usual atmospheric pressure. Should more than a few tenths per cent. of non-volatile matter remain after steam distilling the turpentine, it is probable that petroleum oil is present. This usually betrays itself by the more or less marked blue fluorescence of the residue, but, should this be wanting, the difference in the behaviour of petroleum oil and any non-volatile product of the air oxidation of turpentine itself on digestion with nitric acid will serve to distinguish them. The latter would be readily oxidized and dissolved; the former does not alter much in bulk, but apparently undergoes more or less complete nitration.

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* "J. Soc. Chem. Ind." 1882, 480.

The detection in turpentine of "petroleum spirit," or that portion of crude petroleum which is volatilized by means of steam, is not so easy. The method, recommended by **ARMSTRONG**, is based on the different behaviour of turpentine and paraffins with sulphuric acid. 500 c.c. of the sample are placed with about one-fourth or one-third that quantity of sulphuric acid (2 vols. acid to 1 vol. water) in a well-stoppered bottle, and the mixture somewhat cautiously agitated. It soon becomes heated, and as it is important to effect the polymerization of the turpentine at a temperature not much above the ordinary atmospheric temperature, the bottle is placed in cold water for a time. After repeated agitation with the acid, the turpentine is converted into a viscid oil, and, when this is the case and no more heat is developed on continued agitation, the contents of the bottle are transferred to a separating funnel, the acid layer is run off, and the oil poured into a flask. The latter is then connected with a condenser and a steam-pot—an ordinary tin can will answer—and all that is volatile is distilled off. The distillate is mixed with about half its bulk of sulphuric acid (4 of acid to 1 of water), and treated in precisely similar manner.

The product from this second operation should only consist of a mixture of cymene and the paraffinoid hydrocarbon; in bulk it should not be more than 4 to 5 per cent. of the original hydrocarbon. If much more than 5 per cent. be obtained, it is desirable to repeat the treatment with the acid (4 to 1).

If, from the result of this treatment, it appears probable that petroleum spirit is present, the product is placed in a well-stoppered bottle, together with several times its volume of concentrated sulphuric acid, heated to 50°–60° C., and violently agitated. This operation is repeated, if desirable (weak Nordhausen acid being with advantage substituted for the concentrated sulphuric acid), and the residual hydrocarbon is separated, steam distilled, and then measured. The amount thus obtained should not exceed from ½ to 1 per cent. of the original bulk of the turpentine. This treatment with concentrated acid affords a check on the previous determination.

When American petroleum spirit is itself thus treated, it suffers comparatively little loss, so that the amount of hydrocarbon above 1 per cent. represents the *minimum* amount of petroleum spirit in the turpentine. The spirit from Scotch petroleum contains a very much higher proportion of hydrocarbons alterable by sulphuric acid, and therefore cannot be satisfactorily estimated by this method.

To confirm the presence of petroleum spirit, the turpentine should be distilled. Petroleum spirit commences to distil at a temperature above or below that at which turpentine boils, according to its quality, but always distils within comparatively wide limits of temperature; turpentine commences to boil near 160° C., and almost entirely passes over below 180° C.

The presence of rosin spirit also affects the boiling point of turpentine in a similar manner.

Both rosin oil and petroleum are frequently used in France for the adulteration of turpentine.* Each of these adulterants, especially the former, prevents the drying of paint, with which such adulterated turpentine is mixed, and a rough method of discovering such adulterations is to mix a portion of the suspected sample with a drying oil, and trying it, observing how it dries when painted on the surface of wood or iron.

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* LYTE, "J. Soc. Chem. Ind." 1882, 481.

Owing to their comparatively low bromine absorption power, the presence of the above adulterants would be readily shown in turpentine by the bromine absorption process of MILLS (p. 251).

Natural Order, *Euphorbiaceæ*.

Cascarilla Oil.—*Syn.* OLEUM CASCARILLÆ, L.—From the bark of *Croton eleuteria* (Swartz.), or cascarilla tree. Very fragrant. *Prod.* ·4 to ·75 per cent.; colour, dark-yellow; odour, somewhat like camphor and lemon. Specific gravity, about 0·938.

Natural Order, *Lauraceæ*.

Cassia Oil.—*Syn.* OIL OF CHINA CINNAMON, OLEUM CASSIÆ (Ph. E.), L.—From cassia buds or from cassia bark. Golden yellow; aromatic; fragrant. It is generally adulterated with rectified spirit. Nitric acid converts the pure oil into a crystalline mass. Specific gravity, 1·071 to 1·073; (old) 1·078 to 1·090. *Prod.* from the buds 1 per cent (barely); from the bark of commerce, ·75 per cent. It is frequently sold for oil of cinnamon.

Cinnamon Oil.—*Syn.* HYDRIDE OF CINNAMYL, OLEUM CINNAMOMI (B. P., Ph. L., E., & D.), O. C. VERI, L.—From the bark of *Cinnamomum zeylanicum*, macerated for several days in salt and water, and then distilled. Yellowish or red; very aromatic; odour and taste resemble those of the bark. Specific gravity, 1·035. *Prod.* 11 lb. yield 1 oz. (RAYBAUD).

Oil of cinnamon, owing to its high price, and the consequent premium for its adulteration, can scarcely be obtained pure from the shops of this country. Oil of cassia and highly rectified spirit are the substances usually employed for this purpose. The increased specific gravity resulting from the first, and the diminished specific gravity from the second, afford ready means of detecting these frauds. The presence of oil of cassia may also be detected by an experienced person by the odour, which differs a little from that of pure oil of cinnamon. Oil of cassia is less limpid than oil of cinnamon, and it stands a greater degree of cold without becoming turbid or congealing. "Wine-yellow, when recent; cherry-red, when old; odour purely cinnamonic; nitric acid converts it nearly into a uniform crystalline mass" (Ph. E.). During this reaction the odour of bitter almonds is perceptible. Both oil of cassia and oil of cinnamon are thus converted into a brown balsam; with oil of cassia, however, a brisk decomposition occurs sooner, and at a slighter heat. It also forms a crystalline compound with ammonia. These reactions, unfortunately, are not characteristic. "The most distinguishing characteristic of the cinnamon oils is, perhaps, their relation to the alcoholic solution of caustic potash. Both dissolve in it readily and clear, with a reddish, yellowish-brown colour; after some time, however, the solution becomes very turbid, and a rather heavy undissolved oil precipitates, when the solution gradually becomes clear again" (URE). The palest oil is considered the best.

Oil of cinnamon is chiefly imported from Ceylon, where it is distilled from bark that is unfit for exportation. The dark-coloured oil is usually rectified, when two pale oils are obtained, one lighter, and the other heavier, than water; but 10 per cent. of oil is lost by the process. The oil distilled from the root of the tree (O. CINNAMOMI RADICIS) is much weaker than that from the bark. The oil from the leaves (O. C. FOLIORUM), also imported from Ceylon, smells of cloves, but has a less density than oil of cloves.

Oil of cinnamon consists essentially of hydride of cinnamyl, but, unless when very recently prepared, it also contains a variable proportion of cinnamic acid formed by the oxidation of the hydride.

Sassafras Oil.—*Syn.* VOLATILE OIL OF S., OLEUM SASSAFRAS (Ph. E.), O. LAURI S., O. S. OFFICINALIS, L.—From bruised sassafras chips, the sliced root of *Sassafras officinale*, as oil of cloves. Pale-yellow; highly odorous; hot, pungent, rubefacient, and stimulant; reputed alterative, sudorific, and diuretic, and, as such, used in rheumatism, cutaneous affections, &c. Its main constituent is *safrole* ($C_{10}H_{10}O_2$). Sp. gr., 1·094 to 1·096. *Prod.* 1½ to 2 per cent. (fully).

Pur., *&c.* 1. If the density is lower than 1·094, it is adulterated.—2. Nitric acid acts on this oil, at first slowly, merely turning it of an orange-red, but afterwards with violence, and a reddish-brown resin is formed.—3. Mixed with about one-half its weight of sulphuric acid, a green colour is at first developed, which, by heat, is changed to a blood-red. A large quantity of sulphuric acid acts at once violently, white fumes are given off, and mere charcoal is left.—4. With iodine it forms a permanently clear solution, or at least one that remains so for some time.—5. By agitation with water, it separates into two oils—one lighter, the other heavier, than that fluid.

Natural Order, *Myricaceæ.*

Bayberry Oil.—*Syn.* BAY OIL, OIL OF BAY-LEAVES.—This oil is not to be confounded with the bay oil from the bay or laurel. It is extracted, by means either of wet or dry steam, from the leaves of *Myrica acris.* Two oils are obtained, a "light" oil having specific gravity from about 0·87 to 0·99, and a "heavy" oil, of specific gravity 1·023 to 1·037. The odour of the oil improves by keeping.

Gale Oil.—Obtained by the aqueous distillation of the leaves of *Myrica gale.* Specific gravity, 0·875.

Natural Order, *Myristicaceæ.*

Nutmeg (Volatile) Oil.—*Syn.* OLEUM MYRISTICÆ (B. P., Ph. E.), O. M. MOSCHATÆ (Ph. D.), L.—From the officinal nutmeg or kernel of the fruit of *Myristica moschata.* Nearly colourless; odour and flavour, that of the fruit, but more powerful. By agitation with water, it is separated into two oils—one lighter, the other heavier, than water; the last is butyraceous. Specific gravity, ·948. *Prod.* 4½ to 7 per cent. It is reputed to make the hair grow, and to prevent baldness.

Natural Order, *Piperaceæ.*

Cubebs Oil.—*Syn.* OLEUM CUBEBARUM, O. CUBEBÆ (B. P., Ph. E. & D.), L.—From the fruit of *Cubeba officinalis,* or cubebs, coarsely ground. Aromatic, hot, and bitter tasted; odour, that of the fruit; faintly green, colourless when pure. Specific gravity, ·129. *Prod.* 9 to 11 per cent.

Pur., &c. When pure, iodine has little action on this oil, and immediately gives it a violet colour, without any very marked reaction; nitric acid turns it opaque, and the mixture changes to a pale-red when heated; sulphuric acid turns it of a crimson-red. When adulterated with oil of turpentine, its viscidity, solubility in rectified spirit, and its density are lessened; when mixed with castor oil, it leaves a greasy stain on paper. *Dose,* 10 to 15 drops, in the usual cases in which cubebs in substance is given; 5 to 20 minims (B. P.), suspended in water by mucilage and sugar.

Pepper Oil.—*Syn.* OIL OF BLACK P., OLEUM PIPERIS, O. P. NIGRI, L.—From bruised black pepper (*Piper nigrum*). Colourless, turning yellow; odorous; pungent; not so hot as the spice. Specific gravity, ·9932. *Prod.* 1·25 to

1·5 per cent.; white pepper (of commerce), 1 per cent. (barely).

Natural Order, *Santalaceæ.*

Sandal-wood Oil.—*Syn.* OLEUM SANTALI, O. S. ALBI, L. —From the wood of *Santalum album*, or sandal-tree, and preferably from that of Malabar. It has an odour somewhat resembling that of oil of rhodium, for which it is commonly used; also used to adulterate otto of roses. *Prod.* 9 lb. yield 1 oz. (RAYBAUD).

Natural Order, *Urticaceæ.*

Hop Oil.—*Syn.* OLEUM LUPULI, L.—From commercial hops, by distillation along with water. Colourless, or pale greenish-yellow, according to its degree of purity; odorous; acrid; narcotic; soluble in water; becomes resinous by exposure and age. Specific gravity, ·910. Boiling point, from 257° to 455° F. Chiefly used to increase the aroma and flavour of old or damaged hops. *Prod.* 2 per cent.

Class, MONOCOTYLEDONES.

Natural Order, *Gramineæ.*

Ergot Oil.—*Syn.* ETHEREAL O. OF E., OLEUM ERGOTÆ, O. E. ÆTHEREUM, O. SECALIS CORNUTI, L.—Prepared by evaporating the ethereal tincture at a very gentle heat, and, preferably, allowing the last portion of the ether to escape by spontaneous evaporation. Brownish-yellow; lighter than water; soluble in ether and solution of potash; only partly soluble in alcohol. It appears to be a mixture of volatile and fixed oil, with some resinous matter. *Dose*, 10 to 20 drops, in hæmorrhages; 10 or 12 drops every three or four hours, in diarrhœa; 20 to 50 drops, as a parturifacient, &c. Externally, in rheumatism, toothache, &c.

The above is the oil of ergot now employed in medicine. It must not be confounded with other preparations occasionally called by the same name, but which differ from it in character. Among the latter are the following:—

a. A fixed oil obtained by distilling off the spirit from the alcoholic tincture. It has the odour of rancid fish oil, and the distilled spirit has also a putrid odour.

b. A fixed oil, obtained from coarsely powdered ergot by strong pressure between iron plates, at a heat of about 212° F. It is fluid, coloured, smells strongly of the drug, but is nearly destitute of its leading qualities. Both the preceding contain some volatile oil and resinous matter.

c. An empyreumatic oil obtained by distilling ergot *per se.* It is light-brown, viscid, acrid, and nauseous.

d. A volatile oil obtained by digesting powdered ergot in solution of potash at 125° F., diluting the saponaceous mass thus formed with one-half to an equal weight of water, neutralizing the alkali with dilute sulphuric acid, and then submitting the whole to distillation in a chloride-of-sodium or oil bath. It is white, adhesive, butyraceous, and tasteless. It appears to be a product, rather than a simple educt.

e. This is the ethereal oil, first described, in its purest form. It is colourless, translucent, oily, and acrid-tasted, with the odour of ergot; it has a high boiling point, at which it suffers partial decomposition, but may be volatilized at a lower temperature, like the other oils. By long exposure to heat, it thickens and partly solidifies; light and air darken it; it is lighter than water, very slightly soluble in water, but sufficiently so to impart to it its peculiar odour; it is soluble in pure alcohol, in ether, the volatile and fixed oils, alkaline lyes, liquor of ammonia, creasote, and naphtha. The dilute mineral acids clear it, but do not produce any marked reaction.

Fusel Oil.—*Syn.* GRAIN OIL, MARC BRANDY OIL, POTATO OIL.—Obtained in the manufacture of alcohol from grain, or potatoes, and especially observable in the marc brandy of the South of France. It is a mixture of various alcohols, of which the most prominent is amylic alcohol ($C_5H_{12}O$). If the portion which distils between 260° and 280° F. is collected apart and re-distilled, an oil is obtained having a fixed boiling point of 268°–269° F. Thus purified, it is a thin, mobile liquid, with a suffocating odour and burning taste. When warmed, and dropped upon platinum-black, it oxidizes to *valeric acid*, which bears the same relation to amylic alcohol that acetic acid does to ordinary alcohol.*

Grass Oil.—*Syn.* INDIA GRASS OIL.—From *Andropogon calamus aromaticus* (Royle), supposed to have been the "sweet cane" and "rich aromatic reed from a far country" of Scripture; formerly supposed to be obtained from *Andropogon iwarancusa.* Stimulant and highly fragrant. *See* SPIKENARD OIL.

Spring Grass Oil.—*Syn.* OLEUM ANTHOXANTHI ODORATI, L.—From *Anthoxanthum odoratum*, or sweet-scented vernal grass. It is this oil that gives the very agreeable odour to new hay.

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* *See also* CHURCHILL'S "Technological Handbooks," vol. i. p. 155.

CHAPTER V.

EMPYREUMATIC, MEDICATED, MIXED AND PERFUMERY OILS.

EMPYREUMATIC OILS.

Syn. OLEA EMPYREUMATICA, L.—The "empyreumatic oils" of the old pharmaceutical writers were oily fluids obtained by the dry distillation of various substances, animal, vegetable, and mineral. But few of them are in use at the present day, though formulæ are given for them in some of the foreign Pharmacopœias. Several have useful applications in the arts, and we therefore briefly describe their preparation. When the ingredients are of a liquid or pasty nature, or become so when heated, they are generally mixed with about twice their weight of sand, powdered glass, or other light substance, to divide them, and thus expose them more effectually to the action of the fire. Care must also be taken to provide a well-cooled receiver, which must be furnished with a tube to carry off the non-condensable gases liberated at the same time as the oil. The products of the first distillation are usually purified by rectification, either alone or along with water. In general, they require to be preserved from the light and air.

The following are the principal substances belonging to this class:—

Aloes Oil.—*Syn.* ALOETIC OIL, OLEUM ALOETICUM, L.—

1. From Socotrine or hepatic aloes distilled along with sand. Sp. gr. 0·863. *Prod.* 250 lb. of aloes yield about 1 fl. dr. of oil.

2. (Batavian—CADET DE GASSICOURT.) Olive oil, 1 lb.; hepatic aloes and myrrh, of each in powder, 2 oz.; olibanum, ½ oz.; distil in a sand bath, from a stoneware retort. Used as an external vermifuge for children; a portion is rubbed two or three times a day over the umbilical regions.

Amber Oil.—*Syn.* OLEUM SUCCINI, L.—Coarse pieces of amber, either alone or reduced to powder, and mixed with sand, are submitted to destructive distillation in an iron retort. The oil is separated from the fetid liquor and succinic acid which pass over, and rectified along with about six times its volume of water, by a gentle heat. It then forms RECTIFIED OIL OF AMBER—Ph. L. 1836, O. S. RECTIFICATUM—Ph. D. 1826, O. S. PURISSIMUM—Ph. E. 1841. *Prod.* 20 per cent.

It is a colourless or pale-yellow, thin liquid, with a strong, balsamic odour, a hot, acrid taste, and a neutral, or faintly acid, reaction; heat and air blacken and thicken it; it boils at 186° F. A mixture containing amber oil, 1 part; liquor ammoniæ, 96 parts; alcohol, 24 parts, called *Eau de Luce*, is sometimes used as a remedy for the bites of poisonous animals. (*See also* p. 104.)

Amber Oil, Oxydated.—*Syn.* ARTIFICIAL MUSK.—Put into a cup 1 dr. of oil of amber, and add to it, drop by drop, 3½ fl. dr. of strong nitric acid; let it stand for thirty-six hours, then separate and wash the resinous matter. Antispasmodic and nervine. *Dose,* 5 to 10 gr.; for children, ½ gr. to 1 gr.

Animal Oil.—1. Empyreumatic or Fetid: OIL OF HARTSHORN, DIPPEL'S O., OLEUM ANIMALE EMPYREUMATICUM, O. CORNU CERVI, O. DIPPELII, L.—Chiefly obtained as a secondary product in the manufacture of boneblack. Fetid and dark coloured. Used chiefly to make lampblack.

2. Ethereal: RECTIFIED OIL OF HARTSHORN, OLEUM ANIMALE ÆTHERIUM, O. CORNU CERVI RECTIFICATUM, LOCO OLEI ANIMALIS DIPPELII, L.—*a.* A finer kind of animal oil, made by slowly distilling oil of hartshorn, and collecting only the first portion that comes over. Pale and limpid. Exposure to light discolours it.

b. (Ph. Bor.) Fetid animal oil distilled in a sand bath, and the product rectified with four times its volume of water. White, limpid, fragrant. Light discolours it.

The refined product is said to be antispasmodic, anodyne, and diaphoretic. *Dose,* 5 to 30 drops, in water; in large doses it acts as an irritant poison. (*See also* p. 23.)

Birch Oil.—*Syn.* OLEUM BETULÆ, L.—All parts of the birch contain essential oil—that from the bark being largely prepared in Northern Russia and Germany, by the process given in outline on p. 104. It is said to consist entirely of salicylate of methyl. Saturation with this oil, alone or mixed with fish oil, imparts the peculiar odour to Russia leather.

Box-wood Oil.—*Syn.* OLEUM BUXI, O. B. EMPYREUMATICUM (Ph. L. 1746), L.—From box-wood sawdust. Reputed resolvent; anodyne, antispasmodic, and diaphoretic. *Dose,* 5 to 20 drops; in convulsions, epilepsy, gonorrhœa, &c. Externally, in toothache, &c.

Brick Oil.—*Syn.* OLEUM LATERITIUM (Ph. L. 1746), L. —From olive oil, mixed with brickdust, and distilled; or, from hot bricks steeped in olive oil, then broken to pieces, and distilled.

Brick Oil (Factitious).—*Syn.* OLEUM LATERITIUM FACTITIUM, L.—From linseed oil, 1 lb.; oil of turpentine, ½ lb.; oil of bones or of hartshorn and Barbadoes tar, of each 1 oz.; simply stirred well together. This is generally substituted for the preceding in the shops.

Cade Oil.—*Syn.* OLEUM CADINUM, L., HUILE DE CADE, Fr.—From the *Juniperus oxycedrus*, or Languedoc juniper. Used as oil of tar, which is commonly sold for it.

Guaiacum Oil.—*Syn.* OLEUM GUAIACI, O. G. EMPYREUMATICUM, L.—From guaiacum shavings or raspings. Reputed balsamic, pectoral, and resolvent.

Hartshorn Oil.—Bone oil and rectified bone oil are commonly sold for it, but are inferior to it. *See* ANIMAL OIL (*above*).

Paper Oil. — *Syn.* RAG OIL, PYROTHONIDÆ, OLEUM CHARTÆ, L.—On the small scale, by burning paper on a cold tin plate, and collecting the oil; on the large scale, by the destructive distillation of paper or linen rags. In baldness, toothache, ear-ache, &c.

Rag Oil.—*See* PAPER OIL (*above*).

Soot Oil.—*Syn.* OLEUM FULIGINIS (Ph. L. 1746), L.—From wood-soot. Fetid; reputed antispasmodic and nervine.

Tar Oil.—*Syn.* SPIRIT OF T., OLEUM PINI, O. P. RUBRUM, O. TÆDÆ, O. PICIS LIQUIDÆ, L.—By simple distillation from wood-tar. Reddish and strong scented. By one or more rectifications it becomes colourless and limpid. It soon gets thick. Used in ringworm and several other skin diseases, made into an ointment with lard. It is poisonous if swallowed in large doses.

Tobacco Oil (Empyreumatic).—*Syn.* OLEUM TABACI EMPYREUMATICUM (Ph. U.S.), L.—From tobacco, in coarse powder, gradually heated in a green-glass retort to dull redness, and kept at that temperature as long as any oil passes over; the oily portion is then separated from the water in the receiver, and kept for use. Highly narcotic and poisonous.

Wax Oil.—*Syn.* OLEUM CERÆ, L.—From bees'-wax and sand distilled together; the product is rectified once or oftener. Reputed diuretic. *Dose*, 3 to 6 drops.

MEDICATED OILS.

Syn. OLEA COCTA, O. INFUSA, O. MEDICATA, L. — These are prepared by infusion or decoction. The bruised ingredients are either simply digested in 2 to 4 times their weight of olive oil for some days, or they are gently boiled in it until they become dry and crisp, great care being taken that the heat towards the end of the process is not greater than that of boiling water. As soon as the process is complete, the oil is allowed to drain from the ingredients, which are then (if necessary) submitted to the action of the press. The product is commonly run through flannel or a hair sieve whilst still warm, after which it is allowed to repose for a week or ten days, when the clear portion is decanted from the dregs. The green or recent plants are usually employed for this purpose, but, in many cases, the dried plants reduced to powder and digested for six or eight hours in the oil at the heat of hot water with frequent agitation yield a much more valuable product. They are nearly all employed as external applications only.

The following are the most important preparations of this class:—

Adder's Tongue Oil.—*Syn.* OLEUM OPHIO GLOSSI, L.—From the herb, as OIL OF BELLADONNA. A popular vulnerary.

Ant Oil.—*Syn.* OLEUM FORMICARUM.—Digest 4 oz. of ants in 16 oz. (by weight) of olive oil with a gentle heat, and strain. (*See also* p. 33.)

Balsam Apple Oil.—*Syn.* OLEUM BALSAMINÆ.—*Prep.* Balsam apple (deprived of seeds), 1 oz.; oil of almonds, 4 oz.; digest and strain.

Belladonna Oil.—*Syn.* OLEUM BELLADONNÆ (P. Cod.), L.—*Prep.* From the fresh leaves, bruised, 1 part; olive oil, 4 parts; digested together at a gentle heat until the moisture is evaporated; the oil is then strained off with pressure and filtered. (*See also* p. 36.)

Cantharides Oil.—*Syn.* OLEUM CANTHARIDIS, O. CANTHARIDIBUS, L.—*Prep.* (P. Cod. 1839). From Spanish flies, powdered, 1 part; olive oil, 8 parts; as OIL OF BELLADONNA. Stimulant and rubefacient. Used as a dressing to indolent sores, blisters, &c.; and in dropsy, rheumatism, gout, &c. OIL OF THE OIL-BEETLE (*Meloe proscarabæus*, Linn.) is prepared in a similar manner.

Capsicum Oil.—*Syn.* OLEUM CAPSICI, L.—*Prep.* (Dr. TURNBULL.) From powdered capsicum or Cayenne pepper, 4 oz.; olive oil, 1 pint; digested together for six hours with heat, and strained. Stimulant; rubefacient in colic, cholera, &c.

Chamomile Oil.—*Syn.* OLEUM ANTHEMIDIS, OL. CHAMÆMELI, L.—From the dried flowers (rubbed to pieces), 1 part; olive oil, 8 parts; digested together with heat for six hours. Stimulant, emollient, and vermifuge. (*See also* p. 95.)

Colocynth Oil.—*Syn.* OLEUM COLOCYNTHIDIS, L.—From the pulp, as OIL OF CHAMOMILE. Diuretic. In dropsy, neuralgia, rheumatism, worms, &c.

Earthworm Oil.—*Syn.* OLEUM LUMBRICORUM (E. Ph. 1744).—Washed earthworms, ½ lb.; olive oil, 1½ pint; white wine, ½ pint. Boil gently till the wine is consumed, and press and strain.

Elderflower Oil.—*Syn.* WHITE OIL OF ELDER, OLEUM SAMBUCI ALBUM, O. SAMBUCINUM (P. Cod.), L.—*Prep.* From the flowers, as OIL OF CHAMOMILE. Emollient and discussive.

Elderleaves Oil. — *Syn.* GREEN OIL, GREEN OIL OF ELDER, OIL OF SWALLOWS, OLEUM VIRIDE, O. SAMBUCI VIRIDE, L.—*Prep.* 1. Green elder leaves, 1 lb.; olive oil, 1 quart; boil gently until the leaves are crisp, press out the oil, and again heat it till it turns green.

2. As before, but by maceration, at a heat under 212° F. More odorous than the last.

3. Elder leaves, 1 cwt.; linseed oil, 3 cwt; as No. 1.

The last form is the one usually employed on the large scale. It is generally coloured with verdigris, ½ lb. to the cwt., just before putting it into the casks, and whilst still warm; as, without great skill and a very large quantity of leaves, the deep-green colour, so much admired popularly, cannot be given to it. The oil is got from the leaves by allowing them to drain in the pan or boiler (with a cock at the bottom), kept well heated. Emollient; in common repute as a liniment, in a variety of affections.

Fenugreek Oil.—*Syn.* OLEUM FŒNUGRÆCI, L.—*Prep.* (P. Cod.) From the seeds, as OIL OF CANTHARIDES or of CHAMOMILE. Emollient and resolvent.

Foxglove Oil.—*Syn.* OLEUM DIGITALIS, L.—*Prep.* (P. Cod.) From the fresh leaves, as OIL OF BELLADONNA. Used as an application to chronic ulcers and indurations, painful swellings, &c. As usually met with, it is nearly inert.

Garden Nightshade Oil.—*Syn.* OLEUM SOLANI, L.—*Prep.* (P. Cod.) From the leaves, as OIL OF BELLADONNA. Anodyne and discussive.

Garlic Oil.—*Syn.* OLEUM ALLII INFUSUM, L.—From garlic, as OIL OF BELLADONNA. Used as a liniment in deafness, diarrhœa, infantile convulsions, palsy, rheumatism, &c.

Green Oil.—*Syn.* OLEUM VIRIDI, L.—From bay leaves, origanum, rue, sea wormwood, and elder leaves, of each 2½ oz.; olive oil, 1 quart; as OIL OF ELDER. Detergent, stimulant, and resolvent. Green oil of elder is now usually sold for it.

Hemlock Oil.—*Syn.* OLEUM CONII, L.—*Prep.* (P. Cod.) As OIL OF BELLADONNA.—Anodyne and emollient; in painful ulcers, glandular tumours, &c.

Henbane Oil.—*Syn.* OLEUM HYOSCYAMI, L.—*Prep.* (P. Cod.) As OIL OF BELLADONNA. Used as the last, in various painful local affections.

Iodized Oil, Marshall's.—*Syn.* OLEUM IODATUM.—*Prep.* Oil of almonds, 15 parts; iodine, 1 part. Triturate and digest till dissolved.

Juniper Oil (by Infusion). — *Syn.* OLEUM JUNIPERI INFUSUM, L.—From the crushed berries, as OIL OF BELLADONNA. Diuretic and vulnerary; in frictions, &c.

Lily Oil.—*Syn.* OLEUM LILIORUM, L. — From white lilies, 1 lb.; olive oil, 3 lb.; as OIL OF BELLADONNA. Emollient; used to soften and ripen tumours, indurations, &c.

Melilot Oil.—*Syn.* OLEUM MELILOTI, L.—As the last, avoiding much heat. Emollient and resolvent.

Mucilage Oil. — *Syn.* OLEUM MUCILAGINUM, O. CUM MUCILAGINIBUS, L.—*Prep.* 1. (Ph. L. 1746). Marshmallow root, ½ lb.; linseed and fenugreek seed, of each, bruised, 3 oz.; water, 1 quart; boil one hour, add of olive oil, 2 quarts, and boil until the water is consumed.

2. Fenugreek seeds, 8 oz.; linseed oil, 1 quart; infuse a week, and strain. Once a highly popular emollient application in various local affections.

Mudar Oil.—*Syn.* OLEUM MUDARIS, L.—From mudar bark (in coarse powder), 1 dr.; warm olive oil, ¼ pint; digest twenty-four hours, and strain. Used as an application to cutaneous ulcers, the bites of venomous animals, &c. and as a friction in worms.

Opium Oil. — *Syn.* ANODYNE OIL, OPIATED O., OLEUM OPIATUM, L.—*Prep.* From opium (in powder), 1 dr.; olive oil, 2½ oz.; digest at a gentle heat, with frequent agitation, for five or six hours. The powder should be rubbed in a mortar with a few drops of the oil before adding the remainder. As a local anodyne. The above is the only reliable formula for this preparation. Others are extant, but, whilst the products of several are much stronger, thosc from others have only one-fifth or one-sixth the strength.

Ozonized Oil (Dr. THOMPSON).—*Syn.* OLEO OZONATA.—*Prep.* Pass oxygen gas into the oil (cocoa-nut, sunflower, cod-liver oil, &c.) until it will dissolve no more. Then expose for a considerable time in the direct rays of the sun. Used in phthisis.

Pellitory Oil.—*Syn.* OLEUM PYRETHRI, L.—From bruised pellitory root, as OIL OF BELLADONNA. Used as the last.

Black Pepper Oil (by Infusion).—*Syn.* OLEUM PIPERIS INFUSUM, L.—From black pepper, in coarse powder, as OIL OF CAPSICUM. Stimulant and rubefacient; in frictions.

Poison Oak Oil.—*Syn.* OLEUM RHOIS TOXICODENDRI, L.—From the leaves, as OIL OF BELLADONNA. Externally; in paralysis, &c.

Rhubarb Oil.—*Syn.* OLEUM RHEI, L.—From rhubarb (in powder), 1 part; oil of almonds, 8 parts; digested together in a gentle heat for four hours, and strained, with expression. As an application to indolent ulcers, and as a friction over the abdomen in diarrhœa, English cholera, &c., or as a laxative when the stomach will not bear medicine.

Rose Oil.—*Syn.* OLEUM ROSÆ, O. ROSACEUM, O. R. INFUSUM, O. ROSATUM, L.—*Prep.* From the fresh petals, pulled to pieces, crushed, and digested for two or three days in the sun, or a warm situation, in four times their weight of olive oil, and then pressed, the process being repeated with fresh roses. Ph. E. 1744 and P. Cod. are nearly similar. ALMOND, BEN, or OLIVE OIL, coloured with alkanet, and scented with attar of roses, is now almost universally sold for it. Used for the hair. (*See also* p. 85.)

Rue Oil.—*Syn.* OLEUM RUTÆ (INFUSUM), L.—*Prep.* (P. Cod.). From fresh rue, bruised, as OIL OF CHAMOMILE. Reputed antispasmodic, emmenagogue, stimulant, and vermifuge. In frictions. (*See also* p. 103.)

St. John's Wort Oil.—*Syn.* OLEUM HYPERICI (Ph. L. 1746), O. H. SIMPLEX, BALSAMUM H., L.—From the flowers, 1 part; olive oil, 6 parts; digested together until the oil is well coloured. Antispasmodic, stimulant, and resolvent. A mixture of equal parts of rape oil and green elder oil is usually sold for it.

Scammony Oil.—*Syn.* OLEUM SCAMMONII, O. PURGANS, L.—*Prep.* (VAN MONS.) From scammony (in powder), 1 dr.; hot oil of almonds, 3 oz.; triturate together until cold, and the next day decant the clear portion. *Dose,* ½ to 1 tablespoonful.

Stramonium Oil.—*Syn.* OLEUM STRAMONII, L.—*Prep.* (P. Cod.) From the leaves of thorn-apple or stramonium, as OIL OF BELLADONNA. Anodyne and discussive; as an application to painful tumours, joints, &c.

Tobacco Oil (by Infusion).—*Syn.* OLEUM TABACI, O. T. INFUSUM, L.—From fresh tobacco leaves (bruised), like OIL OF CHAMOMILE. As an application in ringworm, irritable ulcers, pediculi, &c.; and as a friction in itch, neuralgia, painful indurations, &c. It must be used with extreme caution, as it is poisonous.

Toothwort Oil.—*Syn.* OLEUM SQUAMARIÆ, L.—From the herb *Lathræa squamaria* (Linn.), as OIL OF ST. JOHN'S WORT. Astringent and vulnerary. This must not be confounded with another preparation sometimes called "OIL OF TOOTHWORT" (OLEUM PLUMBAGINIS EUROPÆÆ), and which has been occasionally used in itch, as the latter is acrid and apt to cause much irritation.

Wormwood Oil.—*Syn.* OLEUM ABSINTHII, L.—From the fresh herb, as OIL OF LILIES. The P. Cod. and Ph. Wurtem. order only 1 part of the herb to 8 parts of oil. Applied to the abdomen in dyspepsia, diarrhœa, heartburn, worms, &c. It is seldom used in this country. (*See also* p. 96.)

Mixed Oils.

Syn. Compound oils, Olea composita, Olea mixta, L.—Under these names are commonly included various mixtures of oils and other substances that possess an unctuous appearance. When not otherwise stated, they are prepared by simply agitating the ingredients together, and, after a sufficient time, decanting the clear portion, which, in some cases, is then filtered. A few of them only possess any importance. Some of them are, or have been, highly esteemed as popular remedies, and the use of others is confined to veterinary medicine.

The following include the principal mixed oils of the shops, to which the names of a few other compounds, which are frequently called "*oils*," are added for the purpose of facilitating a reference to them:—

Acoustic Oil.—*Syn.* Ear oil, Oleum acousticum, O. terebinthinæ acousticum, L.—*Prep.* From oil of turpentine, 1 part; oil of almonds, 6 parts; mix. In atonic deafness, accompanied with induration of the wax. 1 or 2 drops are poured into the ear, or on a piece of cotton wool, which is then gently placed in it.

Black Oil.—*Syn.* Oleum nigrum, L.—*Prep.* Oil of turpentine, 1 pint; rape oil, 3 pints; oil of vitriol, ¼ lb.; agitate well together with care; then add of Barbadoes tar, 3 oz.; again agitate well, and in ten days decant the clear portion. Linseed oil is preferred for the above by many persons.

British Oil.—*Syn.* Common oil of petre, Oleum britannicum, O. petræ vulgare, L.—*Prep.* From oil of turpentine, 1 quart; Barbadoes tar, 1 lb.; oils of rosemary and origanum, of each 1 oz. Stimulant. Formerly reputed to possess the most astonishing virtues.

Camphorated Oil.—Liniment of camphor.

Carron Oil.—Liniment of lime.

Chabert's Oil.—*Syn.* CHABERT'S EMPYREUMATIC OIL, OLEUM CHABERTI, O. CONTRA TÆNIAM CHABERTI, L.—Oil of turpentine, 3 parts; Dippel's animal oil, 1 part; mix, and distil 3 parts. It must be preserved from the air and light. Used in tapeworm. *Dose,* 1 to 2 teaspoonfuls, in water, night and morning, until 5 or 6 fl. oz., or more, have been taken, a cathartic being given every third day.

Exeter Oil.—*Syn.* OLEUM EXCESTRENSE (Gray).—Green oil, 16 lb.; euphorbium, mustard seed, castor, pellitory, of each 1 oz.; digest and strain. The original form is more complex. The following is also used:—Rape oil, 1½ pint; green oil, ½ pint; oils of wormwood, rosemary, and origanum, of each ½ dr.

Furniture Oil.—*Syn.* MAHOGANY OIL, OIL STAIN.—*Prep.* 1. From refined linseed oil, 1 pint; alkanet root, ¼ oz.; digested together in a warm place until the former is sufficiently coloured, when it is poured off and strained.

2. Pale boiled oil, 1 pint; bees'-wax, ¼ lb., melted together and coloured as before; gives a superior polish, which becomes very tough by age.

3. Linseed or boiled oil, 1 pint; Venice turpentine, pure, 6 oz.; digested, &c., as in the first method.

The above are used for mahogany and other dark-coloured woods.

4. Linseed oil, 8 oz.; vinegar, 4 oz.; oil of turpentine, mucilage, rectified spirit, of each ½ oz.; butter of antimony, ¼ oz.; hydrochloric acid, 1 oz.; mix.

5. Linseed oil, 16 oz.; black resin, 4 oz.; vinegar, 4 oz.; rectified spirit, 3 oz.; butter of antimony, 1 oz.; spirit of salts, 2 oz.; melt the resin, add the oil, take it off the fire, and stir in the vinegar; let it boil for a few minutes, stirring it; when cool, put it in a bottle, and add the other ingredients, shaking all together.

The last two are specially used for reviving French polish.

6. (Pale.) (*a.*) As the preceding, omitting the alkanet.

(*b.*) From nut oil, ¾ pint; bees'-wax, finest, 3 oz., melted together.

(*c.*) To the last add copal varnish, 3 or 4 oz.

The last three are employed for pale woods. They are all applied by means of a rag, and are "polished off" with a woollen rubber or furniture brush. A little strong vinegar, or hydrochloric acid, is sometimes added.

Marshall's Oils.—*Prep.* From linseed oil and rape oil, of each 1 lb.; green oil and oil of turpentine, of each ½ lb.; oil of origanum, ½ oz.; oil of vitriol, ¼ oz.; well shaken together.

Mixed Oils.—*Syn.* OLEUM MIXTUM COMMUNE, L.—*Prep.* From linseed oil and green oil, of each 1 lb.; oil of turpentine, ½ lb.; Barbadoes tar and balsam of sulphur, of each 2 oz.; oils of spike and origanum, of each 1 oz. Stimulant and rubefacient. Used by farriers for sprains, &c. *See* STAMFORD'S OILS (*below*).

Newmarket Oils.—*Prep.* From oils of linseed, turpentine, and St. John's wort, of each 3 lb.; oil of vitriol, 1½ oz.; well shaken together, and the clear portion decanted in a few days. A favourite remedy for sprains in horses.

Nine Oils.—*Syn.* OLD MIXED OILS, OLEUM EX OMNIBUS, L.—*Prep.* From train oil, 1 gall.; oil of turpentine, 1 quart; oil of amber and oil of bricks, of each 5 oz.; oil of spike and oil of origanum, of each 2 oz.; Barbadoes tar, 2½ lb.; oil of vitriol, 2 oz.; camphorated spirit, ½ pint; mixed together as the last. A favourite remedy with provincial farriers.

White Oils.—*Syn.* WHITE EGG-OILS.—1. Yolks of eggs, 4 in number; oil of turpentine, ¼ pint; mix, add of liquor of ammonia, 3 oz.; oil of origanum, ½ oz.; soaper's lye,

¼ pint; water, ¾ pint; agitate well, and strain through a coarse hair sieve.

2. Rape oil, ¾ pint; liquor of ammonia and oil of turpentine, of each 3 oz.; agitate until they form a milk.

3. (Redwood.) Whites and yolks of 2 eggs; oil of turpentine, 1½ oz.; triturate together; add of Goulard's extract, ½ oz.; mix; next add of distilled vinegar, 1½ pint, and, lastly, of rectified spirit, 1½ oz. Stimulant and detergent. Used by farriers.

Petre Oil.—*See* British Oil (*above*).

Phosphorated Oil.—*Syn.* Oleum phosphoratum, L.—*Prep.* 1. (Ph. Bor.) Phosphorus (dried and sliced small), 6 gr.; oil of almonds, 1 oz.; mix; place the phial in hot water, agitate for some time, and, when cold, decant the clear oil from the undissolved phosphorus.

2. (Magendie.) Phosphorus (sliced), ½ dr.; almond oil, 1 oz.; macerate in the dark, with frequent agitation, for fourteen days, then, after repose, decant the clear portion, and aromatize it with a little essence of bergamot.

3. (B. Ph.) *Prep.* Take of phosphorus and oil of almonds, of each q. s. Heat the oil in a porcelain dish to 300° F., and keep it at this temperature for about fifteen minutes, then let it cool and filter it through paper. Put 4 oz. of this oil into a stoppered bottle capable of holding 4½ oz.; then add to it 12 grs. of phosphorus. Immerse the bottle in hot water until the oil has acquired the temperature of 180° F., removing the stopper two or three times to allow the escape of expanded air, then shake the oil and phosphorus together, until the latter is entirely dissolved. *Dose*, 5 to 10 minims.

One oz. of oil dissolves rather less than 5 grs. of pure phosphorus. The large excess ordered in the second formula must be merely for the purpose of increasing the extent of surface acted on. It is, however, with the other precautions given, quite unnecessary. The products of both formulæ have the same strength. *Dose*, 5 to 10 or 12 drops, in milk, barley water, or gruel, or made into an emulsion; in chronic rheumatism, gout, &c., and as a powerful, diffusible stimulant in various diseases with debility and general prostration of the vital powers, &c. Externally, as a friction. Some have thought that it is chiefly to the presence of phosphorus that cod-liver oil owes its wonderful remedial power in these affections.

Quitter Oil.—*Prep.* Red precipitate, 2 dr.; aquafortis, 1 oz.; dissolve, add of olive oil, oil of turpentine and rectified spirit, each 2 oz.; agitate well for three or four hours. Used by farriers for *quitters*, &c.

Radley's Oils.—From Barbadoes tar, ½ lb.; linseed oil and oil of turpentine, of each ¼ pint; gently warmed, and shaken together.

Sulphurated Oil.—*Syn.* BALSAM OF SULPHUR, OLEUM SULPHURATUM, BALSAMUM SULPHURIS, L.—*Prep.* 1. (Ph. L. 1746.) Flowers of sulphur, 1 part; olive oil, 4 parts; boil together in a vessel lightly covered, until they assume the consistence of a thick balsam.—2. (Ph. L. 1824.) Olive oil, 16 oz.; heat it in a sand bath, and gradually add of washed sulphur, 2 oz.; stirring until they combine.

Balsam of sulphur is a dark, reddish-brown, viscid fluid, having an extremely disagreeable and penetrating odour, and a strong, nauseous taste. The local action of balsam of sulphur is that of an acrid and irritant; its remote effects those of a stimulant, expectorant, and diaphoretic. Externally, it is occasionally used as an application to foul ulcers; and was formerly commonly employed internally in chronic pulmonary affections, in doses of 20 to 50 drops. It is now seldom given internally except in veterinary practice.

Sheldrake's Oil.—*Prep.* From pale boiled nut oil and copal varnish, equal parts, melted together by the heat of hot water, and, when perfectly mixed, placed aside in a bottle for a week to settle, after which the clear portion is decanted. Used by artists to grind their colours in to brighten them.

Spike Oil.—1. (*Farrier's.*) From oil of turpentine, 1 quart; Barbadoes tar, 1½ oz.; alkanet root, ½ oz.; digested together for a week. Used as a stimulating liniment by farriers.—2. (*Painter's.*) *a.* From rectified oil of turpentine, 3 pints; oil of lavender, 1 pint; mix. *b.* Oil of turpentine (warm), 5 parts; lavender oil bottoms (genuine), 3 parts; agitate well together, and in a fortnight decant the clear away. Used by artists and enamellers. (*See also* p. 98.)

Stamford's Oils.—*Syn.* LORD STAMFORD'S MIXED OILS. —*Prep.* Dissolve camphor, 1 oz., in rectified spirit of wine, ¼ pint; add oil of origanum, 2 oz.; oil of turpentine, ½ pint; green elder oil, 2 lb.; and agitate until mixed. The rectified spirit is now generally omitted, the camphor being dissolved in the green oil by aid of heat before adding the other ingredients. Stimulant. Used by farriers.

Turpentine Oil (for acoustic use).—*Syn.* OLEUM TEREBINTHINÆ ACOUSTICUM (Mr. MANLE). — Oil of almonds, 4 dr.; oil of turpentine, 40 minims.

Turpentine Oil (Sulphurated).—*Syn.* OLEUM TEREBINTHINÆ SULPHURATUM.—*Prep.* Sulphurated linseed oil, 1 part; oil of turpentine, 3 parts.

Three Oils.—*Syn.* OLEUM DE TRIBUS (VAN MONS), L.— Oils of brick, lavender, and turpentine, equal parts. As a stimulant liniment.

Worm Oil (Canine).—*Syn.* OLEUM VERMIFUGUM CANINUM.—*Prep.* From oil of turpentine and castor oil, equal parts; tinged yellow with a little palm oil or annotta. *Dose*, for a middle-sized dog, ½ oz., repeated in two or three hours if it does not operate.

Ward's Oils.—*Syn.* WARD'S WHITE OILS.—From powdered camphor, rape oil, oil of turpentine, rectified spirit, and solution of potash, equal parts, agitated together for some time, and again before use. Beef brine was formerly used instead of potash.

Wedell's Oils.—*Syn.* BEZOAR OIL, OLEUM BEZOARDICUM, L.—From nut oil, ¼ pint; camphor, ½ oz.; dissolve by a gentle heat, and, when cold, add of essence of bergamot, 1 dr., and let it stand over a little alkanet root until sufficiently coloured.

PERFUMERY OILS.

Syn. SCENTED OILS, OLEA FIXA ODORATA, L.—The oils which usually form the basis of these articles are those of almonds, ben, or olives; but others are occasionally used. The methods adopted for their preparation vary with the nature of the substances whose fragrance it is intended to convey to the oil. The Continental perfumers employ three different processes for this purpose, which they technically distinguish by terms indicative of their nature. These are as under:—

1. A sufficient quantity of the essential oil of the plant, or of the concentrated essence of the substance, if it does not furnish an oil, is added to the fixed oil which it is desired to perfume, until the latter becomes agreeably fragrant; the whole is then allowed to repose for a few days, and, if any sediment falls (which should not be the case when the ingredients are pure), the clear portion is decanted into another bottle. When alcoholic essences are thus employed, the fixed oil should be gently warmed, and the admixture made in a strong bottle, so as to permit of it being corked and well agitated with safety; and in this case the agitation should be prolonged until the whole has become quite cold. In this way all the ordinary aromatized

and perfumed oils of the English druggists and perfumers, as those of bergamot, cassia, cloves, lavender, lemon, millefleurs, neroli, nutmeg, oranges, roses, &c., are made, but those of a few of the more delicate flowers, and of certain other substances, can only be prepared of the first quality by one or other of the processes described below.

In general, 1 to 1½ dr. of the pure essential oil, or 3 to 4 dr. of the alcoholic essences, are found sufficient to render 1 pint of oil agreeably fragrant. ½ dr. of pure attar of roses is, however, enough for this purpose, owing to the very powerful character of its perfume; but even a less quantity than this is commonly employed, on account of its costliness, the deficiency being made up by a mixture of the oils of rhodium, rosemary, and bergamot. Most of the oils of this class are intended for hair cosmetics.

2. (By INFUSION.) Dry substances, after being reduced to powder, or sliced very small—flowers or petals, after being carefully selected, and picked from the stems and other scentless portions—and soft or unctuous matters, as ambergris, civet, or musk, after being rubbed to a paste with a little oil, either with or without the addition of about twice their weight of clean sand or powdered glass, to facilitate the reduction, are digested in the fixed oil for about one hour, at a gentle heat obtained by means of a water bath, continual stirring being employed all the time; the mixture is then removed from the heat, covered up, and left to settle until the next day, when the clear portion is decanted into clean bottles. When flowers are employed, the free oil is drained off, and the remainder obtained by the action of a press. The process is then repeated with fresh flowers, five or six times, or even oftener, until the oil is sufficiently perfumed. For ambergris, musk, or civet, the digestion is generally continued for fifteen to twenty days, during

which time the vessel is either freely exposed to the sunshine, or kept in an equally warm situation.

The first quality of the oils of ambergris, balsam of Peru, benzoin, cassia, cinnamon, civet, orange flowers, orris, roses, styrax, and vanilla are made by infusion.

3. (By THE FLOWERS.)—*a.* Upon an iron frame a piece of white, spongy, cotton cloth is stretched, and then moistened with almond or olive oil, usually the latter; on the cloth is placed a thin layer of the fresh-plucked flowers; another frame is similarly treated, and in this way a pile of them is made. In twenty-four or thirty hours the flowers are replaced by fresh ones, and this is repeated every day, or every other day, until seven or eight different lots of flowers have been consumed, or the oil is sufficiently loaded with their odour. The oil is then obtained from the cotton cloth by powerful pressure, and is placed aside in bottles to settle, ready to be decanted into others for sale. Sometimes thin layers of cotton wool, slightly moistened with oil, are employed instead of cotton cloth.

The oils of all the more delicate flowers, such as those of honeysuckle, jasmin, or jessamine, jonquil, may-blossom, myrtle-blossom, narcissus, and violet, are generally prepared in the above manner.

b. The native perfumers of India prepare their scented oils of bela, chumbul, jasmin, &c., in the following manner:—A layer of the scented flowers, about 4 inches thick and 2 feet square, is formed on the ground; over this is placed a layer of moistened tel or sesamum seeds, 2 inches thick, and on this another 4-inch layer of flowers. Over the whole a sheet is thrown, which is kept pressed down by weights attached round the edges. The flowers are replaced with fresh ones after the lapse of twenty-four hours, and the process is repeated a third and even a fourth time when a very highly scented oil is desired. The swollen sesamum seeds, rendered fragrant by contact with the flowers, are then submitted to the action of the press, by which their bland oil is obtained strongly impregnated with the aroma of the flowers. The expressed oil is then set aside in dubbers (bottles made of untanned hides) to settle. We have employed poppy seed in this country, in a similar manner, with great success.

c. The flowers are crushed in a mortar or mill, with one-half their weight of blanched sweet almonds, and the next day the mass is gently heated and submitted to the action of a powerful press; the liquid thus obtained is allowed to repose for a week, when the upper portion of oil is decanted and filtered. This plan is occasionally adopted in this country for the oils of roses and of a few other flowers. (*See also* Preparation of Essential Oils, p. 64.)

The solution of a few grains of benzoic acid, or of gum benzoin (preferably the first), in any of the above oils will materially retard the accession of rancidity, if it does not prevent it altogether.

The oils of the last two classes (2 and 3) are chiefly used to impart their respective odours to the simple oils, pomades, &c.; and in the manufacture of scented spirits or *esprits.* The following formulæ are given as examples of both classes of preparations:—

Ambergris Oil.—From ambergris, 2 dr.; oil, 1 pint; by infusion. (*See also* p. 31.)

Benzoin Oil.—From gum benzoin, 7 dr.; oil, 1 pint; by infusion.

Hair Oil.—*Syn.* HUILES ANTIQUES, Fr.—These are numerous. All those scented with the simple perfumes are prepared in the way explained under class 1 (*above*). The selection depends entirely upon the judgment of the operator or the fancy of the purchaser. In general, a mixture of two or three perfumes is preferred in these countries to the pure fragrance of any single flower, and [illegible] grossness of taste is exhibited in these matters, which surprises our Continental neighbours, and the inhabitants of Italy more particularly. Some of these oils are coloured. A red tinge is given to them by allowing the oil to stand for a few hours over a little alkanet root (2 dr. to the pint) before scenting it. The application of a gentle heat facilitates the process. Yellow and orange are given by a little annotta or palm oil; and green, by steeping a little green parsley or lavender in them for a few days; or by dissolving 2 or 3 dr. of gum guaiacum in each pint by the aid of heat, and, when cold, decanting the clear portion. Huile antique au jasmin, huile antique à la fleurs d'oranges, huile antique à la rose, huile antique à la tuberose, huile antique à la violette, &c., are simple oils flavoured with the respective perfumes or their preparations.—Huile antique rouge à la rose is the ordinary oil of roses coloured with alkanet root. —Huile antique verte is simple oil coloured green, as above, and scented.—Huile antique aux millefleurs is so scented with several perfumes that none predominate. A mixture of bergamot, lemons, lavender, neroli, pimento, and ambergris or musk is commonly employed for the purpose.

Macassar Oil.—*Syn.* HUILE DE MACASSAR.—*Prep.* 1. (ROWLAND'S.) Oil of ben or almonds (reddened by alkanet root), 1 pint; oils of rosemary and origanum (white), of each 1 dr.; oil of nutmeg and attar of roses, of each 15 drops; neroli, 6 drops; essence of musk, 3 or 4 drops.

2. (DE NAQUET.) Oil of ben, 1 quart; nut oil, 1 pint; rectified spirit, $\frac{1}{4}$ pint; essence of bergamot, $3\frac{1}{2}$ dr.; tincture of musk and esprit de Portugal, of each 2 dr.; attar of roses, $\frac{1}{2}$ dr.; alkanet root, q. s. to colour.

Marrow Oil (Perfumed).—1. Simple marrow oil, scented at will.

2. (FLUIDE DE JAVA.) Marrow oil, coloured with a little palm oil and scented.

3. (HUILE COMOGENE.) Marrow oil, 4 oz.; spirit of rosemary, 1½ oz.; oil of nutmeg, 12 drops.

4. (HUILE PHILOCOME D'AUBRIL.) Cold-drawn nut oil and marrow oil, equal parts; scent at will, q. s.

5. (HUILE DE PHÉNIX.) Clarified beef marrow, lard, pale nut oil, and expressed oil of mace, of each 4 oz.; melt together by the heat of hot water, strain through linen into a warm stone mortar, add of oils of cloves, lavender, mint, rosemary, sage, and thyme, of each ½ dr.; rectified spirit, 1 oz., in which has been dissolved by a gentle heat balsam of tolu, 4 dr.; camphor, 1 dr.; triturate until the whole is cold, and then put it into bottles. All the above are used to make the hair grow, and to prevent it falling off.

Musk Oil.—From grain musk, 1 dr.; ambergris, ½ dr.; oil of lavender, 20 drops; oil, 1 pint, by infusion. A second quality is made by working the same ingredients, after the oil is poured from them, with ¾ pint of fresh oil. This also applies to OIL OF AMBERGRIS and HUILE ROYALE.

Musk and Ambergris Oil.—*Syn.* HUILE ROYALE.—From ambergris, 2 dr.; grain musk, ½ dr.; oils of cassia, lavender, neroli, and nutmeg, of each 10 drops; oil, 1 pint, by infusion. (*See above.*)

Styrax Oil.—From liquid styrax (pure), 5 dr.; oil of nutmeg, 10 drops; ambergris, 6 grs.; oil, 1 pint, by infusion.

Vanilla Oil.—*Syn.* HUILE À LA VANILLE.—From purest olive or almond oil, 1½ pint; vanilla (finest, in powder), 2 oz.; oil of bergamot, 1 dr.; attar of roses (finest), 15 drops; by infusion.

CHAPTER VI.

WAXES.

Wax.—*Syn.* CIRE (Fr.), WACHS (Ger.).—The substances known as wax are obtained partly from animal and partly from vegetable sources.

They contain oxygen in small quantity, consisting chiefly of the members highest in the series of fatty acids, $C_nH_{2n}O_2$, partly free and partly in combination with alcohol radicals, but differ from fats in not containing glyceryl.

The waxes are solid at common temperatures—melt below the temperature of boiling water—are sparingly soluble, or insoluble, in alcohol—soluble in ether, chloroform, bisulphide of carbon, and in the volatile and fixed oils.

The following are the chief waxes of commercial importance :—

1°. ANIMAL WAXES.

Bees'-wax.—*Syn.* YELLOW WAX, CERA (Ph. L.), CERA FLAVA (B. P., Ph. E. & D.), L.—This is the substance which forms the cells of bees, and is obtained by melting the comb in water after the honey has been removed, straining the liquid mass, remelting the defecated portion, and then casting it into cakes.

Pure bees'-wax has a pleasant, waxy odour, a pale yellowish brown colour, and the specific gravity 0·960 to 0·965. It is brittle at 32° F., softens and becomes plastic at 88° or 90° F., and melts at 154°–155° F. "It becomes kneadable at about 85° F., and its behaviour when worked between finger and thumb is characteristic. A piece the size of a pea being worked in the hand till tough with the warmth, then placed upon the thumb and forcibly stroked down with the fore-finger, curls up, following the finger, and is marked by it with longitudinal streaks" (B. S. PROCTOR). It is very frequently adulterated with farina, resin, mutton-suet or stearin, and paraffin. Dr. NORMANDY met with a sample containing 23 per cent. of sulphate of soda. The first may be detected by oil of turpentine, which dissolves only the wax; the second, by its solubility in cold alcohol and by its terebinthinate taste; the third, even when forming less than 2 per cent. of the wax, by the sample yielding sebacic acid on distillation. Paraffin may be detected by alteration in specific gravity, and by the method of HEHNER (*see* p. 149). A spurious bees'-wax met with in the American markets is described in "New Remedies" for 1877, and is said to have been a very clever imitation externally of the genuine substance, which it closely resembled in appearance, colour, fracture, bitterness, pliability, and odour. Upon analysis, it was found to be composed of 60 parts of paraffin and 40 parts of yellow resin, covered with a thin coating of pure bees'-wax. The specific gravity of the counterfeit article was identical with that of many samples of true bees'-wax. Saline matter may be detected by the loss of weight when a weighed quantity of the wax is boiled with water. Heavy substances, as chalk, plaster of Paris, white lead, oxide of zinc, &c., may also be thus separated, since they subside, owing to their superior gravity, to the bottom of the vessel. The rough mealy fracture of pure wax is rendered finer grained, smoother, and duller by the addition of lard or spermaceti, and becomes sparkling and more granular by the addition of resin (PROCTOR).

White Wax.—*Syn.* BLEACHED WAX, CERA ALBA (B. P., Ph. L., E., & D.), L.—Prepared by exposing pure bees'-wax in thin flakes to the action of the sun, wind, and rain, frequently changing the surface thus exposed, by remelting it, and reducing it again to thin flakes. It is used in making candles, and in white ointments, pomades, &c., for the sake of its colour. Block white wax (CERA ALBA IN MASSIS) is the above when cast into blocks; the best foreign white wax is always in this form. Virgin wax (cake white wax, CERA ALBA IN OFFIS) should be the last made into round flat cakes; but this is seldom the case, the mixture sold under the name generally containing from one-third to one-half its weight of spermaceti. The "white wax" supplied by certain wholesale druggists to their customers is alleged to be often totally unfit for the purposes to which it is applied. Mr. B. S. PROCTOR* states that wholesale houses of the highest reputation supply as white cake wax an article which is in many cases half spermaceti.

Spermaceti.—*Syn.* CETACEUM (B. P., Ph. L., E., & D.).—This is the solid fat which is dissolved in sperm oil in the head cavity of the sperm whale (*Physeter macrocephalus*), and which, after death, separates as a solid.

The oil is filtered from the solid fat, the latter is heated with potash solution, and afterwards melted. Thus purified, it is white, scaly, brittle; specific gravity, 0·943 at 15° C.; melting point, 38°–47° C.; neutral, inodorous, and nearly tasteless.

Chemically, spermaceti is chiefly cetylic palmitate, $C_{16}H_{31}O_2 (C_{16}H_{33})$.

It is demulcent and emollient, and chiefly used in ointments and cerates.

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* "Chemist and Druggist," iv. 1863.

2°. VEGETABLE WAXES.

Carnauba Wax.—This is obtained from the leaves of the carnauba palm, *Copernicia cerifera*, a native of Brazil. The leaves are collected and dried, and the wax, which can then be peeled off, is melted in earthen pots, from which, when cold, it is turned out. It is brittle, and of a yellowish colour. It melts at about 83°–84° C., and its sp. gr. is about 0·99.

It is extensively used in the manufacture of candles. Mr. Consul MORGAN, in a paper laid before Parliament in 1876 on the trade and commerce of Brazil, states that the exportation of this wax is calculated at 871,400 kilos., exceeding in value £162,500.

Japan Wax.*—There are three principal sources of this fat or tallow in Japan, *Rhus succedanea*, L., *Rhus vernicifera*, D.C., and *Rhus sylvestris*. The first two, according to Prof. J. RIEN. of Marburg, are not natives of Japan, but were probably introduced from the Loochoo Islands. *R. sylvestris*, however, is a true native of Japan, but is only cultivated for domestic use, the commercial products being furnished by *R. succedanea* and *vernicifera*.

The usual method of obtaining the wax is the following: —The fruits are previously well dried, and then ground by means of mill-stones, or in mortars with wooden pestles, or by bamboo flails. They are then freed, by sifting and winnowing, from shells and epidermis; sometimes, however, these latter are not separated. The mass is then heated over boiling water in order to melt the fat in the cells, which is then expressed by means of different presses. During the second pressing, a little fatty oil is occasionally added to the mass in order to retard the congelation of the fat. The crude tallow thus obtained is now boiled with dilute lye, whereby it becomes granular and more susceptible to the bleaching process, then exposed to the sun, and several times melted with water. The bleaching and melting are repeated until the product is pure and white.

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* A. MEYER, "Year Book of Pharmacy," 1880, 218.

Formerly, the wax was only imported in round cakes of about $4\frac{7}{8}$ inches in diameter and 1 to $1\frac{3}{16}$ inch in thickness; but at present it occurs also in square cakes, or blocks, the latter of about 143 lb. each. When freshly broken, the fractured surface is almost white, or, sometimes, slightly yellowish-green and the odour is tallow-like and disagreeable. Its sp. gr. is about 0·916. It melts at 52°–53° C. when old, and at 42° C. when recently solidified. At 30° C. it is soluble in about 700 parts of 97 per cent. alcohol. Warm ether dissolves it readily, but deposits it in flakes or granular masses on cooling.

Japan wax is chiefly used in Europe and in the United States for mixing with bees'-wax in the manufacture of candles, as it facilitates the removal of the latter from the moulds; it is also used in the manufacture of wax matches. Shoe and furniture makers likewise use it in considerable quantity as an ingredient in polishing materials. For pharmaceutical purposes, such as ointments, it is not well adapted, since it is, like bleached bees'-wax, already a rancid substance, and promotes the rapid deterioration of fats mixed with it. Perfumers make use of it for preparing a castor-oil pomade, a mixture of castor oil and Japan wax having the property of becoming entirely transparent by repeated melting.

The following are some other vegetable waxes of minor importance:—

Chinese Wax.—*Syn.* PELA WAX.—Produced by an insect (*Coccus pe-la*) upon young branches of *Fraxinus chinensis.* Melts at about 82°–83° C.

Chinese Vegetable Tallow.—*Syn.* STILLINGIA TALLOW.—Obtained from kernels of *Stillingia sebifera.* Melts at about 40° C. Used in China for making candles.

Myrica Wax.—*Syn.* MYRTLE TALLOW.—This is a solid fat obtained by pressure from the berries of *Myrica cerifera.* Sp. gr. 1·005 (MOORE). Melts at 47°–49° C. (MOORE).

Palm Wax.—Obtained from trunk of *Ceroxylon andicola.* The crude wax does not melt below the temperature of boiling water.

Sugar-cane Wax.—*Syn.* CEROSIN.—Obtained by rasping the bark of the cane, and purifying by recrystallization from boiling alcohol. Its composition is said to be $C_{48}H_{96}O_2$. Melts at about 82° C.

Fossil Wax.—*See* OZOKERIT.

Mineral Wax.—*See* PARAFFIN.

3°. ARTIFICIAL WAXES.

Factitious Wax.—*Syn.* CERA FLAVA FACTITIA, L.—A spurious compound sold by farriers' druggists for veterinary purposes.

Prep. 1°. From yellow resin, 16 lb.; hard mutton suet, or stearin, 8 lb.; palm oil, 2½ lb.; melted together.

2°. As last, but substituting turmeric, 1 lb., for the palm oil.

3°. Best annotta, 6 oz., or q. s.; water, 1 gallon; boil; add of hard mutton suet or stearin, 35 lb.; yellow resin, 70 lb.; again boil, with constant agitation, until perfectly mixed and of a proper colour, and, as soon as it begins to thicken, pour out into basins to cool. When cold, rub each cake over with a little potato starch.

Modelling Wax.—*Prep.* Take of bees'-wax, lead plaster, olive oil, and yellow resin, equal parts; whiting, q. s. to form a paste; mix well, and roll into sticks. Colours may be added at will.

Sealing Wax.—1. *Red.*—(*a*) Take of shellac (very pale), 4 oz.; cautiously melt it in a bright copper pan over a clear charcoal fire, and, when fused, add of Venice turpentine, 1¼ oz.; mix, and further add of vermilion, 3 oz.; remove the pan from the fire, cool a little, weigh it into pieces, and roll them into circular sticks on a warm marble slab by means of a polished wooden block; or it may be poured into moulds whilst in a state of fusion. Or the sticks, when cold, may be polished with a rag.

(*b*) Shellac, 3 lb.; Venice turpentine, 1¼ lb.; finest cinnabar, 2 lb.; mix as before.

Both the above are "fine."

(*c*) As 1 (*a*), but using half less vermilion. Inferior.

(*d*) Resin, 4 lb.; shellac, 2 lb.; Venice turpentine and red lead, of each 1½ lb.; as before. Common.

2. *Black.*—(*a*) Shellac, 60 parts; finest ivory black, reduced to an impalpable powder, 30 parts; Venice turpentine, 20 parts. Fine.

(*b*) Resin, 6 lb.; shellac and Venice turpentine, of each 2 lb.; lampblack, q. s. Inferior.

3. *Gold-coloured.*—By stirring gold-coloured mica spangles, or talc, or *Aurum musivum* into the melted resins just before they begin to cool. Fine.

4. *Marbled.*—By mixing two or three different coloured kinds just as they begin to cool.

5. *Soft.*—(*a*) Red. Bees'-wax, 8 parts; olive oil, 5 parts; melt, and add of Venice turpentine, 15 parts; red lead, to colour.

(*b*) Green. As the last, but substituting powdered verdigris for red lead. Both are used for sealing official documents kept in tin boxes; also as cements.

6. *Bottle-wax.*—(*a*) Black. Black resin, 6½ lb.; bees'-wax, ½ lb.; finely powdered ivory black, 1½ lb.; melted together.

(*b*) Red. As the last, but substitute Venetian red, or red lead, for ivory black.

All the above formulæ for "fine" wax produce "superfine" by employing the best qualities of ingredients, and "extra superfine," or "scented," by adding 1 per cent. of balsam of Peru, or liquid storax, to the ingredients when considerably cooled. The "variegated" or "fancy" coloured kinds are commonly scented with a little essence of musk or ambergris, or any of the more fragrant essential oils. The addition of a little camphor, or spirit of wine, makes sealing wax burn easier. Sealing wax containing resin, or too much turpentine, runs into thin drops at the flame of a candle.

Testing Bees'-wax.—If the specific gravity is higher than 0·964, it indicates the presence of stearin, resin, or Japan wax; and if lower than 0·956, paraffin, ozokerit, or tallow may be suspected.

Chloroform, or fatty oils, form a clear solution with dry, and a slightly turbid solution with moist, wax. By treating pure bees'-wax with a saturated solution of borax at 80° C., the aqueous solution is rendered turbid. When Japan wax, or stearin, is present, a milky solution is obtained, remaining opaque after cooling.

By boiling wax with a solution of soda (1 : 6), pure wax gives a translucent solution—if milky, stearin may be present; if pasty or stiff, Japan wax may have been added.

When the specific gravity is less than 0·956, and the wax behaves with borax and soda like pure wax, paraffin or ozokerit is indicated.

HEHNER's method of analysis of bees'-wax (yellow).—The following particulars are extracted from OTTO HEHNER's elaborate paper on the analysis of bees'-wax: †—

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* HAGER, "Dingl. Polyt. J." 238, 356; "J. Chem. Soc." xl. 316.

† "Analyst," 1883, 16.

Process.—Alcoholic potash solution is made from pure potash, and from spirit which has been distilled from caustic alkali. Each c.c. should correspond to from 0·3 to 0·4 c.c. of normal acid. Two or three standardizing experiments must be made, and the average taken. From 3 to 5 gms. of the wax are weighed on a watch-glass, transferred to a flask holding about 400 c.c. and heated with about 50 c.c. of methylated spirit distilled from alkali. When the wax is perfectly liquefied, alcoholic phenol-phthaleïn solution is added in not too small amount. The phenol-phthaleïn must not be acid, as it generally is, but must be rendered pink by a few drops of alkali. The alcoholic potash solution is then added drop by drop from a burette, the mixture being kept well agitated, until the pink colour is permanent. The number of c.c.'s added is then read off, and an excess of the alcoholic potash solution is run into the flask, 50 c.c. being the quantity which Mr. HEHNER generally uses. The whole is then *briskly* boiled, under a reflux condenser, for one hour. If any particle of wax hang above the level of the fluid on the sides of the flask, shake well from time to time. After one hour the solution should be clear, or nearly so. The excess of potash is then titrated back with standard sulphuric acid, the fluid being kept boiling. From the data thus obtained, the free acid (calculated as cerotic acid, $C_{26}H_{53}.CO.OH$) and the saponifiable substance (calculated as myricine, $C_{16}H_{31}(C_{30}H_{61})O_2$) are obtained. An actual experiment will render the above details clearer :—

Wax used, 3·7417 gms. KHO (10 c.c. of which = 4·64 c.c. normal sulphuric acid) required to neutralize free acid, 2·82 c.c. Total KHO added, 49·96 c.c. Titrated back with 16·97 c.c. normal acid. Hence cerotic acid = 0·5371 gm. or 14·35 per cent., and myricine = 3·3124 gms. or 88·55 per cent. Total, 102·90. As the result of the analysis of eighteen English and seventeen foreign samples, HEHNER finds, as regards the English, that the free acid (calculated as *cerotic*) varies from 13 to 16 per cent., the average being 14·40 per cent., and the saponifiable matter (calculated as *myricine*) from about 86 to 89·6 per cent., the average being 88·09 per cent. In all cases the sum of the cerotic acid *plus* myricine is somewhat higher than 100, the average amount being 102·49. The tendency of these figures is to show that English bees'-wax consists almost completely of cerotic acid and myricine, but that it also contains a small quantity of a substance of lower molecular weight, probably LEWY's *ceroleine.*

The fluctuations in the case of the foreign samples was found to be much more considerable than in the above, and point to a greater degree of sophistication.

HEHNER classifies the actual and possible adulterants of wax thus :—

1°. *Acid substances,* embracing the solid fatty acids, mainly palmitic and stearic, and the acids of resin, particularly sylvic acid.

2°. *Neutral, but saponifiable compounds,* such as stearin and palmitin, Japanese wax, spermaceti, and carnauba wax.

3°. *Non-saponifiable bodies.*—The only representative of this class, for practical purposes, is paraffin. The presence of an adulterant belonging to class 1° would be indicated by increase in the acidity, calculated as cerotic acid, and decrease in the saponifiable matter, calculated as myricine. An adulterant of class 2° would, on the other hand, decrease the calculated proportion of cerotic acid and increase that of the myricine. As to class 3°, the addition of paraffin would lower both the amounts of cerotic acid and of myricine. The specific gravity of the sample would also be lowered.

Distinction of Waxes.*—Heat the sample with 10 times as much chloroform to boiling, and, when complet dissolved, cool in cold water.

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* HIRSCHOLM, "Pharm. J." [3] x. 749; "Year Book of Pharmacy," 1880, 143.

I. The chloroform solution remains clear.

A. *Ether dissolves completely—Myrica wax.*

B. *Ether dissolves incompletely.* A portion is boil with ten times the quantity of alcoholic potash soluti till saponified, and the soap heated with 100 volun of water.

(*a*) *Soap completely soluble—Japanese wax.*
(*b*) *Soap partially soluble.—Bees'-wax.*

II. The chloroform solution becomes cloudy.
Carnauba wax.

CHAPTER VII.

MINERAL OILS.

Syn. HYDROCARBON OILS.—The principal kinds of mineral oils met with in commerce are Boghead or Bathgate naphtha, coal naphtha, shale naphtha, naphtha from caoutchouc, native naphtha or petroleum, and their derivatives.

As in the case of the animal and vegetable oils, we may arrange the mineral oils according to their origin:—

1°. *Crude oils obtained by distillation of bituminous shales, cannel coal, coal-tar, lignite, or peat.*

2°. *Crude oils occurring ready-formed in various parts of the world.*

1°. CRUDE OILS OBTAINED BY DISTILLATION of bituminous shales or schists, cannel, Boghead, or Bathgate coal.

For many years the manufacture of burning oils by the distillation of bituminous schists has been extensively carried out on the Continent, but the discovery which formed the foundation of the modern manufacture was made nearly thirty years ago by our countryman, Mr. JAMES YOUNG. This gentleman took the lease of a spring of petroleum at Alfreton, in Derbyshire, in 1847, and, after numerous experiments, succeeded in obtaining two useful oils from the crude liquid; the one being adapted for lubricating machinery, and the other for burning in lamps. The almost total cessation of the flow of petroleum terminated the business after two years' working, and led YOUNG to institute a series of experiments to try if petroleum could be produced artificially by the destructive distillation of coal. These experiments resulted in the discovery of an oil which he named "paraffin oil," as it had many of the chemical properties of the solid *paraffin* discovered twenty years before by REICHENBACH in beech-wood tar. YOUNG'S patent (dated October 7, 1850) involved the slower distillation of coals, at a lower temperature than had hitherto been employed for the purpose, and this change in practice was followed by the novel result of a copious production of liquid hydrocarbons. The gas or cannel coals were found to yield the liquids in largest quantities, that variety known as Boghead coal, or Torbane Hill mineral, being specially adapted for the patented process.

The following is a brief outline of YOUNG'S process:—

Boghead coal,* broken into small fragments, is introduced into perpendicular tubes or retorts, about 11 feet in height, by conical hoppers at their upper extremities. Four of these tubes constitute a set, being built into one furnace, and charged by a single workman. They pass completely through the furnace, and are closed below by dipping into shallow pools of water, while the openings into the hoppers above may be shut by valves. The coal in each tube is gradually heated as it descends to that part which passes through the furnace, and when it reaches the bottom of the tube it has parted with its volatile constituents, and is raked away as refuse, the coal from above descending as it is removed. Thus the action of these perpendicular retorts is continuous, and the distillation goes on uninterruptedly both day and night. The vapours produced are conducted by iron tubes to the main condensers, which consist of a series of syphon pipes freely exposed to the air. The quantity of incondensable gas formed is inconsiderable; and it is this result, so different from that obtained in the ordinary gasworks, that marks the great value of YOUNG's process. The crude oil, a dark-coloured, thick liquid, is then distilled to dryness in large iron cylindrical stills, and is thus freed from the excess of carbon, which is left behind as coke. The oil, after distillation, is further purified by being acted upon by strong sulphuric acid, which chars the principal impurities, and causes them to subside in the form of a dense black, heavy acid tar. To separate the remaining impurities and that portion of the sulphuric acid which remains in the oil, it is next subjected to the action of caustic soda. Thus purified, the paraffin oil contains four distinct commercial products. To effect their separation, the process of fractional distillation is employed.

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* When the supply of Boghead coal became exhausted, recourse was had to the bituminous schists or shales of the lower carboniferous formation which abound in West- and Mid-Lothian.

1°. The *first* elevation of temperature drives over the lighter and more volatile portions, which, when purified by a subsequent distillation, yield the fluid known as "paraffin naphtha," "petroleum spirit," "benzoline." This product is used as a substitute for "turps," as a solvent for india-rubber, for cleaning gloves, and for burning in those naphtha lamps so much employed by costermongers, and workmen in railway tunnels and similar situations. On the perfect separation of this naphtha the safety of the burning oil depends.—2°. This burning oil, the "paraffin oil" of commerce, comes over at a much higher temperature than the naphtha. It is a perfectly safe lamp oil, and has a greater illuminating value than any other oil in the market. Its properties are noticed below.—3°. The *third* product in point of volatility, is a comparatively heavy liquid (machinery oil), largely used for lubricating purposes.—4°. From this oil, and others which come over at a very high temperature, the *fourth* commercial product is separated by the action of artificial cold. This last product is the beautiful translucent solid paraffin, now much used as a candle material.

In many parts of Germany the extraction of the crude oil or tar from bituminous substances is effected in ovens. In these ovens the bituminous body is thrown upon a layer of burning fuel which covers the bottom of the oven, the result being that the bituminous matter is resolved into gaseous bodies which are lost, and tar which flows downwards toward the burning fuel, which, being covered with a layer of clay, is prevented from entering into violent combustion. This method, however, is only had recourse to on a small scale, since it is found that in most cases the tar obtained by means of it is not of a kind suited for yielding paraffin and paraffin oils.

The preparation of the tar or crude oil from fossil fuel, of the character already specified, constitutes one of the most delicate and difficult branches in the manufacture of paraffin oils, and paraffin, &c. The chief sources of failure to be avoided are the overheating of the oil vapour, and consequent decomposition (varying in amount) into useless gaseous products, and its inefficient condensation.

It has been shown by VOHL that, even when the construction of the retorts is not of the best, an average yield of tar may be obtained by the proper condensation of the vapours. "The complete condensation of the vapours of the tar is one of the most difficult problems the mineral oil and paraffin manufacturer has to deal with, while the means usually adopted for condensation, such as large condensing surfaces, injection of cold water, and the like, have proved ineffectual. It has often been attempted to condense the vapours of tar in the same manner as those of alcohol, but there exist essential differences between the distillation of fluids and dry distillation. In the former case the vapours soon expel all the air completely from the still and from the condenser, and provided, therefore, that, in reference to the size of the still and bulk of the boiling liquid, the latter be large and cool enough, every part of the vapour must come into contact with the condensing surfaces. In the process of dry distillation, however, the case is entirely different, because with the vapours, say of tar, permanent gases are always generated. On coming into contact with the condensing surfaces, a portion of the vapours is liquefied, leaving a layer of gas as a coating, so to speak, on the condensing surface. The gas, being a bad conductor of heat, prevents to such an extent the further action of the condensing apparatus that a large proportion of the vapours is carried on, and may be altogether lost. A sufficient condensation of the vapours of tar can be obtained only by bringing all the particles of matter which are carried off from the retorts into contact with the condensing surface, which need neither be very large nor exceedingly cold, because the latent heat of the vapours of tar is small, and consequently a moderately low temperature will be sufficient to condense those vapours to the liquid state. The mixture of gases and vapours may be compared to an emulsion such as milk, and as the particles of butter may be separated from milk by churning, so the separation of the vapours of tar from the gases can be greatly assisted by the use of exhausters acting in the manner of blowing fans. It is of the utmost importance in condensing the vapours of tar that the molecules of the vapours be kept in continuous motion, and thus made to touch the sides of the condenser. The condenser should not be constructed so that the vapours and gases can flow uninterruptedly in one and the same direction."

An important condition for the safe and quiet distillation of the tar, or crude oil, when obtained is that it should be free from water. Unless the removal of the water is effectually accomplished, the tar may boil over during its distillation, and, coming into contact with the fire under the still, may give rise to an alarming conflagration. The dehydration of the tar is effected in an apparatus constructed for the purpose, consisting of an iron tank placed within a larger tank, a space of about two inches intervening between the two tanks is filled with water, which is heated to, and kept at a temperature of between 60° and 80° C., for ten hours, by the end of which time the ammoniacal water, having separated from the lighter tar, is drawn off by a stop-cock placed at the bottom of the tank, whilst the tar is decanted through a valve at the top.

An improvement in the distillation process has been patented by Mr. NORMAN HENDERSON, of the Broxbourn Oil Company. The purified once-run oil is fractionated continuously in a connected series of three cylindrical stills. Each still is fitted with inlet and outlet pipes, the mouths of which, opening upwards, are placed at opposite extremities of the still. The outlet pipe of No. 1 passes as inlet into No. 2, and similarly the outlet of No. 2 is connected as inlet with No. 3, while the outlet of No. 3 passes into one or more common residue stills. The inlet, or feed pipe, of No. 1 traverses the long horizontal condensing pipes of the whole three, and thus the once-run oil, while absorbing heat before entering No. 1 still, also aids the condensation of the vapours; or, alternatively, it coils through No. 2, taking up heat there. In working, there is a constant feeding of heated once-run oil into No. 1 still, a like steady flow from No. 1 to No. 2, from No. 2 to No. 3, and from No. 3 to a residue still. The oil, of course, increases in density as it passes onwards; but the specific gravity in each still is practically constant, and, as the heat applied is in proportion to the gravity, the oil vaporized in each still is of uniform quality and specific gravity. In No. 3 still, where, in consequence of the high gravity and temperature, there is a tendency to deposit carbonaceous matter, circulating plates or dishes hinged to each side of the still, and concentric with the bottom shell, are placed. The circulation of the oil from the bottom up the sides in the space between the shell and the circulating plates is directed and assisted by jets of steam from a pipe laid along the bottom of the still. In this way the oil is kept in steady circulation up the sides and down the centre, and any deposit of coke which may take place forms on the inner side of the circulating plates, from which there is provision for its easy removal when required. The advantages claimed for this system are—(1°) The stills may be worked continuously for weeks, or months, without stopping. (2°) Impurities and heavy oil never accumulate in any still, but pass on till they reach the final residue or coking still. (3°) The quality of the products is much improved. The oils possess more equal gravity and constant boiling point, and the paraffin scale is of better colour, crisper, and more easily pressed than with the ordinary method. (4°) A saving of 50 per cent. in plant, because, with continuous working and steadily maintained temperature, a set of three stills in twelve days will pass through 285,000 gallons of oil, while the same stills in the same period under the old system can work off not more than 126,000 gallons. (5°) A saving of about 60 per cent. in the labour of working the still. (6°) The quantity of fuel used is only about one-half of that required by the old method.*

The manufacture of oils and paraffin from cannel coal is thus conveniently summarized by Dr. FRANKLAND:—

1°. The coal is distilled in such a way as to get the maximum amount of paraffin, and much depends on the manner in which the distillation is performed. A high temperature gives a large quantity of gas, but comparatively little paraffin; a low temperature much paraffin, and but little gas. Besides paraffin, several analogous bodies are produced—marsh gas itself, hydrides of ethyl and propyl probably, also hydrides of butyl, amyl, and others. The crude oil which first comes over is of a dark-brown colour, and contains from 1 to about 5 per cent. of paraffin.

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* "Oil Trade Review," Oct. 4, 1884.

2. The crude product is then exposed to a current of steam in a close vessel, till all the volatile products are taken away; *e.g.*—coal-naphtha, containing benzol, and the lower hydrides belonging to this series, as hydride of amyl. The residue contains the higher members of the marsh-gas family up to paraffin, which is probably not a single substance, but a mixture of several solids belonging to this family, as its melting point varies in different samples.

3. After the treatment by steam, the oily and non-volatile residue is treated with concentrated sulphuric acid to remove the diatomic radicals, homologous with ethylene, which it contains. These are readily absorbed by the acid.

4. The oil is then removed from the acid, which has become jet-black, and agitated with strong caustic soda to remove a product of the action of the acid on the oil which remains dissolved. After agitation, this forms a layer between the oil at the top and the soda at the bottom, and the oil can easily be run off from the two lower strata.

5. The separated oil is then rectified, and three products are obtained.

No. 1 is sold as illuminating oil—*kerosene.*

No. 2 is sold as *paraffin oil* for lubricating purposes. It is mixed with Gallipoli oil to give it consistence.

No. 3 is crude paraffin, which solidifies on cooling.

The waste carbolate of soda resulting from the treatment of the oil with the caustic alkali is decomposed by sulphuric acid, and the liberated carbolic acid is utilized either as a disinfectant, or for saturating railway sleepers; and sometimes as a source of certain tar colours; or it may be used in the manufacture of gas, the soda which remains in the coke being extracted by lixiviation. The waste sulphuric acid combined with the ammoniacal liquors that always accompany the first stages of the distillation of the tar is made into sulphate of ammonia.

Purification of the Crude Paraffin.—1. The crude solid is placed in a centrifugal machine, by which paraffin oil is expelled from its pores.

2. The residual mass is cast into cakes, placed in layers on cocoa-nut matting on hollow iron plates containing water to regulate temperature, and submitted to hydraulic pressure. As much as possible is squeezed out in the cold, and then the temperature is gradually raised to from 35° to 40° C., by which means the paraffins of lower melting points are squeezed out, the object being to produce a paraffin with a high melting point, so as to make it like wax or spermaceti. The remaining cakes are of a dark-brown colour.

3. To further purify these cakes, they are melted, heated to 155° C., and 2 per cent. of sulphuric acid added to remove any of the C_nH_{2n} bodies still present.

4. The cakes are again melted with soda, cooled, and again submitted to pressure, well washed with hot water, cooled, mixed with cold, colourless naphtha to assist filtration, and then filtered through animal charcoal to remove colouring matters.

5. It is next placed in steam-jacketed wrought-iron cylinders, and superheated steam passed through to remove naphtha. The residue is then pressed, and cast into cakes.

Pure paraffin thus obtained is a colourless, inodorous, tasteless, translucent solid. Sp. gr. 0·870. Melts at 45° to 65° C. Boils at 370° C. Insoluble in water, and only slightly so in alcohol. Sulphuric and nitric acids and chlorine are without action upon it in the cold. Chlorine passed through melted paraffin slowly attacks it with evolution of hydrogen alone. This last reaction establishes its position among members of the marsh-gas family.

Paraffin is now largely used for making candles, for which purpose it is specially adapted, being a most elegant substance, and surpassing all other candle materials, even spermaceti, in illuminating power. Its property of not being acted upon by acids or alkalies renders it suitable for stoppers for vessels holding chemical liquids, for electrotype moulds, and for coating the inside of casks. It is not acted upon by ozone, so that it has been employed with advantage in experiments on this body for rendering air-tight joints formed by the union of glass tubes. As it contains no oxygen, it might be used to protect oxidizable metals like sodium and potassium from contact with the air. One use of paraffin candle-ends may be referred to—a small piece added to starch will be found to give a gloss and brilliancy of surface to starched linen that can be obtained by no other addition.

A patent has been taken out* to prevent caoutchouc materials from hardening and cracking, by steeping them in a bath of melted paraffin for a few seconds or several minutes, according to their size, and then drying in a room heated to about 100° C.†

The members lower than solid paraffin in the marsh-gas series are also valuable as illuminants, and are sold under the name of *paraffin oil.* The production of this oil, as described above, and of a similar material from petroleum, or rock oil, has almost again revolutionized our artificial lighting.

Lignite, or brown coal, is extensively used on the Continent for preparing paraffin and paraffin oil.* The following are the final products of the distillation:—

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* No. 18740, Aug. 1881.

† "J. Soc. Chem. Ind." 1882, 415.

(*a*) *Volatile oils*, called *photogen*, and *solar oils*, for illuminating. Of these there are three qualities:

1°. *Photogen*	S.G. 0·785 to 0·795		Clear and colourless.
2°. *Photogen*	„	0·805	Rather yellow.
3°. *Solar oil*†	„	0·835	Yellow.

(*b*) *Paraffin.*

(*c*) Volatile spirit, called *benzol.*

(*d*) *Phenol, or carbolic acid.*

Bituminous deposits in the Camamū basin, Brazil, have been recently visited and examined by Mr. J. Macdonald Cameron, M.P., who considers that they may in the future afford an important supply of oil. The material, locally known as "turfa," is called *brazilite*, and appears to be a kind of brown coal, or lignite. The deposits are said to exist over an area of at least 300 square miles, but the outcrop is not continuous. According to the analysis of Mr. W. Wallace, of Glasgow, the yield of crude oil per ton of "turfa" is 68 gallons of specific gravity 0·888, and the ultimate products of refining are:—

		Per 100 galls. crude oil.
Burning, or light oil	S.G. 0·812	36·3
Intermediate oil	„ 0·884	31·1
Heavy, or lubricating oil	„ 0·955	9·7
Paraffin scale, or crude paraffin		0·55
Loss in refining		22·35
		100·00

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* Hofmann's Report on Chemical Products and Processes in International Exhibition of 1862.

† The name *solar* oil is applied also to the heavier portions of shale and petroleum oils.

Solid paraffin	per ton of "turfa,"		3¾ lb.
Sulphate of ammonia	„	„	6¼ „

It will be seen from the above figures that the yield of solid paraffin is small. The light or burning oil is nearly colourless and of fine quality, resembling petroleum rather than paraffin oil. The intermediate oil is suitable for lighthouses and railway carriages.

Peat Oil.—In 1849 it was attempted to obtain paraffin and paraffin oil from peat in Ireland, but the quantity procured in this way—only 2 gallons per ton of peat—was found to be too small to be remunerative. It is interesting to note that the first paraffin candle was made by Messrs. J. C. & J. Field, in 1852, from a sample of paraffin prepared by the Irish Peat Co. under Rees Reace's patent.

Paraffin is prepared from wood-tar in the following manner:—Distil beech-tar to dryness, rectify the oily portion of the product, which is heavier than water, until a thick matter begins to rise; then change the receiver, and moderately urge the heat as long as anything passes over; next digest the product in the second receiver in an equal measure of alcohol of 0·833, gradually add 6 or 7 parts more alcohol, and expose the whole to a low temperature; crystals of paraffin will gradually fall down, which, after being washed in cold alcohol, must be dissolved in boiling alcohol, when crystals of pure paraffin will be deposited as the solution cools.

The solid paraffin obtained from cannel coals, brown coal, or lignite, and shales does not exist ready formed therein, but is the product of destructive distillation. American petroleum, or "rock oil," however, contains it ready formed to the extent of about 2½ per cent., and Burmese petroleum yields from 5 to 10 per cent. Solid deposits of paraffin are also met with in the neighbourhood of the Caspian Sea. (*See* OZOKERIT, p. 185.)

Coal Naphtha.—One of the products of the distillation of coal-tar. The light oil, after separation from the heavier "creasote oil," or "dead oil," is rectified, whereby a further portion of heavy oil is separated and crude *coal oil* is obtained. This is agitated with sulphuric acid to free it from organic bases, and the supernatant liquid, after further rectification, yields the "highly rectified naphtha," or "benzole" of commerce, which is chiefly a mixture of five oily hydrocarbons of the benzene series—viz.:

Benzene	C_6H_6	Boiling point	80·4° C.
Toluene	C_7H_8	„ „	114° C.
Xylene	C_8H_{10}	„ „	126° C.
Cumene	C_9H_{12}	„ „	144° C.
Cymene	$C_{10}H_{14}$	„ „	177·5° C.

The *basic* constituents of crude coal naphtha, which are removed by agitation with sulphuric acid, may be obtained in the free state by distilling the acid liquid with excess of alkali, and separated from one another, partly by fractional distillation, and partly by fractional crystallization of their platinum salts. These bases belong to two series, one represented by the general formula $C_nH_{2}{}_{-5}N$—viz.:

Pyridine	C_5H_5N
Picoline and its isomer Aniline	C_6H_7N
Lutidine	C_7H_9N
Collidine	$C_8H_{11}N$

The other series $C_nH_{2n-11}N$, isomeric with chinoline, C_9H_7N, and its homologues—viz.:

Leucoline	C_9H_7N
Iridoline	$C_{10}H_9N$
Cryptidine	$C_{11}H_{11}N$

"Dead oil," the less volatile portion of coal-tar, contains a considerable quantity of carbolic acid or coal-tar creasote, with other bodies more imperfectly examined.

Coal naphtha has a more disagreeable odour than native naphtha, and is denser, its sp. gr. ranging from 0·860 to 0·900.

A glance at the tabular statement on p. 167, prepared by Mr. S. B. BOULTON, will help to make plain the position of the naphthas among the numerous other products of the distillation of coal.

Caoutchouc Oil.—*Syn.* CAOUTCHOUCIN. — This is an extremely light fluid obtained by distilling india-rubber.

Barnard's patent process is as follows:—India-rubber or caoutchouc, as imported, cut into small lumps, of about 2 cubic inches each, is thrown into a cast-iron still, connected with a well-cooled worm tub (any flat vessel with a large evaporating surface will do, the entire top of which can be removed for the purpose of cleaning it out); and heat is applied in the usual way, until the thermometer ranges to about 600° F., when nothing is left in the still but dirt and charcoal. The dark-coloured fetid oil which has distilled over is next rectified along with one-third of its weight of water, once or oftener; and at each rectification it becomes brighter and paler, until at about sp. gr. 0·680 it is colourless, and slightly volatile. The product is then shaken up with nitro-hydrochloric acid, or chlorine, in the proportion of ¼ pint of acid to 1 gallon of the liquid. To enable the dirt to be the more easily removed from the bottom of the still, common solder, to the depth of about ½ an inch, is thrown on. *Prod.* 80 per cent.

Mixed with alcohol, caoutchoucin dissolves gums and resins, especially copal and india-rubber, at the common temperature of the atmosphere, and it speedily evaporates, leaving them again in the solid state. It mixes with the oils in all proportions. It has been used in the manufacture of varnishes, and for liquefying oil paints, instead of turpentine. It is very volatile, and requires to be kept in close

Table showing most important products derived from Newcastle coal, when carbonized by the usual method for the manufacture of gas (S. B. BOULTON).

- COAL.
  - 1. Coal Gas.
  - 2. Gas liquor
    - *Liquid ammonia.*
    - *Ammonic sulphate.*
    - *Ammonic chloride.*
    - *Ammonic carbonate.*
  - 3. Coal-tar
    - Oils lighter than water, or crude naphthas.
      - Benzol
        - *Nitro-benzol.*
        - *Aniline.*
      - Toluol...
        - *Nitro-toluol.*
        - *Toluidine.*
      - Xylol } Solvent and burning naphthas
        - *Nitro-xylol.*
        - *Xylidine.*
      - Cumol } Solvent and burning naphthas
        - *Nitro-cumol*
        - *Cumidine.*
      - Pyridine.
      - Carbolic acid
        - *Picric acid.*
        - *Aurin.*
      - Cresylic acid.
    - Oils heavier than water, otherwise "dead oil," or heavy oil of tar; commonly called creasote.
      - Carbolic acid.
      - Cresylic acid.
      - Other tar acids.
      - Naphthalene
        - *Nitro-naphthalene*
        - *Naphthylamine* ...
          - *Naphthol.*
          - *Phthalic acid.*
      - Leucoline or Quinoline series, *e.g.*, cryptidine.
      - *Phenanthrene
        - *Phenanthrene Quinone.*
        - *Diphenic acid.*
      - *Carbazol.
      - *Anthracene or paranaphthalene
        - *Anthraquinone.*
        - *Anthraquinone sulphonic acid*
          - *Alizarin.*
          - *Purpurin.*
      - *Acridine.
      - *Pyrene ... *Pyrene quinone.*
      - *Chrysene ... *Chryso-quinone.*
      - Benzerythrene.
    - Pitch.
  - 4. Coke.

The substances which can be separated as they come over from the still, by filtration or other simple process, are in ordinary type. Those prepared by further chemical treatment are in *italics*.

The direct products of the dead oils are arranged as nearly as possible according to their respective volatilities, and to the order in which they come over from the still.

For the manufacture of *pure* carbolic, cresylic, and other tar acids, further and elaborate treatment is required.

Those marked with an asterisk are "green" oils distilling from 550° to 750° F.

vessels. According to the researches of HIMLY, GREGORY, and BOUCHARDAT, the caoutchoucin of BARNARD consists of several liquids, some of which have the composition of olefiant gas, and others that of oil of turpentine.

Caoutchouc oil is a great preventive of rust, and has been adopted for this purpose in the German army.* It is applied by means of a piece of flannel over the metallic surface, and allowed to dry. To remove it, the article is treated with caoutchouc oil again, and washed after twelve to twenty-four hours.

The Mineral Oil Trade of Scotland has grown to great importance since the date of Young's patent in 1850. The capital invested amounts to about £2,000,000. Difficulty has, however, been experienced in maintaining a footing against the American natural supply, and the Scottish industry could hardly have continued to exist, under such circumstances, unless there had been great skill in utilizing waste products. The original horizontal retorts have been completely superseded by the "vertical," and various improvements on the vertical, such as Henderson's and Young and Beilby's retorts are now in use, though apparently not with uniform success. For instance, the directors of the Midlothian Oil Co. have recently advised a discontinuance of the "Henderson" and also of the "Young and Beilby" process, and a return to the vertical retort, in order to effect a saving. On the other hand, at the Oakbank Oil Co.'s works, retorts known as the Beilby pattern of the "Young and Beilby" patent have given satisfaction under the supervision of the inventor, and at the Burntisland Oil Works the "Henderson" retorts are used with complete satisfaction. At the works of the Clippen Oil Co. the "Henderson" retorts have been replaced by the "Pentland," an adaptation, or alteration, by Mr.

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* "Chem. Zeitung," vi. 477.

YOUNG of the "Young and Beilby." It may be termed a duplicate or composite retort, the top portion consisting of iron, into which the shale is first placed, and where it is distilled at the lowest heat adapted for the production of scale, after which the coke or residue is dropped into a bottom chamber, constructed of fire-brick, where high temperatures are employed, and a large yield of ammonia successfully liberated. The advantages claimed for it are (1°) that it secures the *maximum* yield from shale of its two most valuable products, scale and ammonia, as by other processes any increase of one was only obtained by the diminution of the other; (2°) the partial purification of the oil under the most favourable conditions before it leaves the retort, thus effecting a considerable saving.

Refrigerating processes are more important and more used than formerly. Much solid paraffin used to be allowed to go away in solution in the oils. At one time the prices of the solid and liquid were much nearer to each other, so that it was not of so much consequence, whereas now the relative prices of the liquid and solid are as 6*d.* to 2*s.* 6*d.*[*]

The following figures, representing the annual production at Young's Paraffin Light and Mineral Oil Co.'s works, will give an idea of the relative proportions of commercial products obtainable from shale:—

Shale distilled	500,000 tons
Crude oil distilled and refined .	16,000,000 galls.
Burning oil	6,500,000 ,,
Naphtha	900,000 ,,
Heavy lubricating oil . .	9,000 tons
Solid paraffin	6,000 ,,
Sulphate of ammonia . .	4,000 ,,

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[*] "Oil Trade Review," 1885.

Definite Character of Destructive Distillation.—Prof. MILLS, F.R.S., in an interesting paper,[*] considers that the results of all kinds of destructive distillation are of a definite nature, and that they cannot be susceptible of indefinite variation, because the law of multiple proportions must apply, without exception, to every one of them, though it has been hitherto customary to regard them as if of indefinite character, and open to a vast variety of modification at the hands of the chemical inventor. In his work on Destructive Distillation,[†] Prof. MILLS has shown that the organic matter in a good average Scotch shale has almost exactly the composition $C_6H_{10}O$. The changes which this undergoes at a low temperature may be represented by the equation

$$7C_6H_{10}O = 18C + C_{24}H_{62}O_3 + 4H_2O.$$

		Fixed Carbon.	Gas and Oil.	
(Calculated)	100	31·5	58·0	10·5
(Found)		31·2	58·3	10·5

At a high temperature we have

$$7C_6H_{10}O = 6C + C_{36}H_{62}O_3 + 4H_2O.$$

		Fixed Carbon.	Gas and Tar.	
(Calculated)	100	10·5	79·0	10·5
(Found)		12·8	76·0	11·2

The Heywood cannel gas coal, which represents an average Scotch cannel, gives the following reactions:—

At a low temperature,

$$4C_9H_{12}O = 27C + C_9H_{46}O_3 + H_2O.$$

		Fixed Carbon.	Gas and Tar.	
(Calculated)	100	59·6	37·1	3·3
(Found)		58·1	38·3	3·6

At a high temperature,

$$4C_9H_{12}O = 24C + C_{12}H_{46}O_3 + H_2O.$$

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[*] "J. Soc. Chem. Ind." 1885, 325.

[†] Second Edition, p. 28.

		Fixed Carbon.	Gas and Tar.	
(Calculated)	100	52·9	43·8	3·3
(Found)		52·5	43·9	3·6

The results for Boghead coal are as follow :—

At a low temperature,

$$3C_{12}H_{20}O = 15C + C_{21}H_{58}O_2 + H_2O.$$

		Fixed Carbon.	Gas and Oil.	
(Calculated)	100	33·3	63·3	3·3
(Found)		33·3	64·1	2·6

At a high temperature,

$$3C_{12}H_{20}O = 6C + C_{30}H_{58}O_2 + H_2O.$$

		Fixed Carbon.	Gas and Tar.	
(Calculated)	100	13·3	83·3	3·3
(Found)		12·8	84·6	2·6

Thus considerable evidence is obtained in favour of the definite character of the destructive distillation of coal and shale. It is probable that the organic matter in these minerals can be always represented with an nC_3 formula, and that a very simple relation exists between the C of the fixed carbon on the one hand and the C of the gas and tar (or oil) on the other. It is clear also that C_3 is the fundamental unit, or stable condition, in these effects, and that not less than this unit must be removed from, or left in, the "fixed carbon" during destructive distillation. Hence it is hopeless to expect that, for instance, more than fractional variations in the yield of oil from a shale can be effected in modern retorting.

2°. CRUDE OILS EXISTING READY-FORMED.—The various names, *naphtha, mineral naphtha, mineral tar, petroleum, rock oil, liquid bitumen, Erdöl, Steinöl,* are applied somewhat loosely to certain inflammable liquids occurring naturally in various localities. The term "naphtha" (Gr. *νάφθα* = rock oil) is traced to a Persian word *Nafata,* meaning *to exude,* and was originally applied to an inflammable liquid which exudes from the soil in various parts of Persia. The word was extended to the similar fluids so exuding in different parts of the world, and more recently has been applied to many of the inflammable liquids, produced by the dry distillation of organic substances, resembling true naphtha chiefly in inflammability and volatility—*e.g.*, products of the distillation of wood and coal are respectively called *wood naphtha* and *coal naphtha.* Generally, it may be mentioned that the thinner and least coloured mineral oils, or the more volatile portions of the native oils, are called naphthas, while the darker and more viscid kinds are called mineral tar, and the intermediate varieties are called petroleum (*petri-oleum* = rock oil).

Native Naphtha, or Petroleum, is found in Japan, Burmah, shores of the Caspian Sea, Siberia, Italy, Spain, France, Germany, Galicia, Moldavia, Roumania, Great Britain, United States, Canada, &c., and quite recently it has been found at Sibi, in Southern Afghanistan. It occurs, as stated by Prof. DEWAR,* in lines intimately connected, for the most part, with the principal mountain chains of the world. For instance, "on the American continent it is met with along a line extending from Point Gaspé, in Canada, to Nashville, Tennessee; and in Europe and Asia along a line extending from Hanover, on the North Sea, through Galicia, the Caucasus, and the Punjaub. These are the principal lines. In America it also occurs on the Pacific coast from the Bay of San Francisco to San Diego; again, from Northern Nebraska to the mouth of the Sabine river, on the Gulf of Mexico; again, from Havana, near the western end of Cuba, through San Domingo and the Leeward and Windward Islands to Trinidad, thence westward on the mainland to the Magdalena river, and southward from that point to Cape Blanco, in Peru."

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* Lecture on "American Oil and Gas Fields," Society of Arts, May 20, 1885.

"In Europe and Asia bituminous deposits also occur on the lower Rhine and in the valley of the Rhone; from Northern Italy, following the Apennines to Southern Sicily; along the eastern shores of the Adriatic, through Albania into Epirus; along the depression in which lie the Jordan and the Dead Sea; along the mountains bordering the valley of the Tigris on the east; from Western China, through Burmah, Pegu, Assam, Sumatra, Java, and Japan."

Petroleum varies greatly in character, in density, in boiling point, in colour, &c., from the thin, light, colourless fluid of Persia, with sp. gr. about 0·750, to a substance as thick as butter and about as heavy as water. The products of shallow wells in America are, generally speaking, darker than those of deep wells.

Various suggestions have been made to account for the occurrence of native naphthas. It is most generally believed that the chief cause is the decomposition, at great depths beneath the earth's surface, of vegetable and animal remains, but it is by no means known with any certainty how this decomposition has been brought about, whether it is still going on, or whether the process has long ceased to be in active operation. MENDELEJEFF [*] supposes that, as a consequence of the condensation of the earth's substance from vapours, the interior must consist of metals, chiefly iron, in combination with carbon, and that water, acting on these carbides at high temperatures and pressures, produced metallic oxides and hydrocarbons, which latter, rising in a state of vapour, became condensed in the superincumbent strata, especially in porous sandstones. Most probably, however, more than one cause has been at work, and possibly the American deposits occurring in Palæozoic strata may be due to causes differing from those which have originated the Russian petroleum occurring in Tertiary formations.

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[*] "Revue Scientifique," Nov. 1877.

Petroleum can rarely be procured without boring wel from which it is obtained by pumping, or, in some cases, l means of buckets and windlass. In America the boring very rapidly accomplished. Prof. Dewar states that wel of 1500 to 2000 feet in depth are pierced in from abou one to two months.*

The oil is largely conveyed from the neighbourhood of the wells by pipes, and these pipe-lines have, since 1865, become a great feature of the American oil industry. The oil from many thousand wells is passed through these pipes, the aggregate length being several thousand miles, worked by various companies.

American Petroleum consists chiefly of paraffins of the C_nH_{2n+2} series, from C_4H_{10} to $C_{15}H_{32}$.

By fractional distillation, sometimes with aid of steam, ordinary or superheated, and purification of the distillate by potash, a number of commercial products are obtained. The lighter oils are useful as solvents for resins, &c., and the heavier for burning in lamps and as fuel for steam-boilers. Of these the following may be noticed:—

1°. *Rhigolene.*—Boiling point, 30° C. Employed as an anæsthetic.

2°. *Petroleum Ether* (I.).—*Syn.* RHIGOLENE, SHERWOOD OIL.—This distils over at 45° to 60° C. Boiling point, 50° to 60° C. Sp. gr. about 0·665. Absorbs oxygen from the air, and becomes heavier (sp. gr. then 0·670 to 0·675). It is extremely inflammable. Used as a remedy for rheumatic pains and as a local anæsthetic.

3°. *Petroleum Ether* (II.).—*Syn.* GASOLINE, CANADOL.—Distils at between 60° and 70° C. Sp. gr. 0·665.

4°. *Petroleum Benzine.*—Distils at between 70° and 120° C. Sp. gr. 0·680 to 0·700. Dissolves in alcohol and ether. Boils at 60° to 80° C. Absorbs oxygen and increases in weight. Dissolves fats, caoutchouc, asphalt, and turpentine —less easily colophony, mastic, and dammar resin. It kills all small animal organisms, and is used externally for itch and other cutaneous affections. Internally it has been employed for gastric pains. It is also used for the extraction of oils and fat, for the preservation of anatomical specimens, the carburation of illuminating gas, and the preparation of lacquers and varnishes.

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* For a very full account of the apparatus used at the wells. see Spon's "Encyclopædia of the Industrial Arts," div. iv. p. 1441 et

5°. *Ligroïn* is a similar distillate used for the ligroïn or "Wonder" lamps.

6°. *Artificial Turpentine Oil.—Syn.* PETROLEUM SPIRIT, POLISHING OIL.—Distils at between 120° and 170° C. Sp. gr. 0·740–0·745. Does not dissolve resins. Used for diluting linseed-oil varnish and for cleaning printers' types.

7°. *Illuminating Oil.* — *Syn.* PETROLEUM, KEROSENE, PARAFFIN OIL, REFINED PETROLEUM.—Sp. gr. 0·78 to 0·81. Flashing point (*open* test), 90° to 110° F. Igniting point, 110° to 130° F. Includes all the intermediate distillates from crude petroleum from sp. gr. 0·76 to 0·83.

8°. *Lubricating Oil.*—Sp. gr. 0·850 to 0·915. Mixed with rape, olive, or lard oil, is an efficient lubricator. "Vulcan" oil is petroleum of sp. gr. 0·87 to 0·89, purified by sulphuric acid, and mixed with 5 per cent. rape oil. "Opal" oil is petroleum of sp. gr. 0·85 to 0·87 similarly purified and mixed with rape oil.*

Alsace Oils differ from American in being partly absorbed by fuming sulphuric acid, and by being converted by nitric acid into nitro-products.

Egyptian Petroleum has a much greater specific gravity than American, and does not contain the lighter oils. It yields an excellent lubricating oil, and in its crude state is well adapted for heating steam boilers, there being but little risk.

The following are some of the properties of different American oils, according to GESSNER :—

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* WATTS' "Dictionary of Chemistry."

Pennsylvanian Oil.—Dark coloured, with peculiar greenish lustre or fluorescence by reflected light. Sp. gr. from 0·782 to 0·820. When refined, the distillate yields from 75 to 85 per cent. of illuminating oil. The heavy oils produced in the distillation yield paraffin, and they are also suitable for lubricating.

Mecca (Ohio) Oil remains fluid at very low temperatures. Sp. gr. from 0·890 to 0·910.

Canadian, or Enniskillen, Oil is dark coloured, and has a peculiar and offensive smell. It yields a larger quantity of burning oil than Pennsylvanian. Sp. gr. from 0·860 to 0·880, and that of the rectified burning oil about 0·838.

Californian Oil, sp. gr. 0·927, yields the following when refined :—

Illuminating oil	38	per cent.
Lubricating ,,	48	,,
Pitch	10	,,
Water	4	,,

Another Californian sample yielded—

Light oils	5	per cent.
Burning oils	50	,,
Light machine oils	20	,,
Heavy oil and paraffin	25	,, *

The following figures, Dr. TILDEN states, represent approximately the results of the distillation of American petroleum. The oil in the tanks at common temperatures, especially in summer time, evolves a good deal of gas, and more is given off on first applying heat.

First condensable distillate, or naphtha, including gasoline, benzoline, and heavier "benzenes"	6 to 15	per cent.
Burning oil (two qualities)	75 to 80	,,
Residue (which, by separate distillation. yields lubricating oil)	8 to 10	,,

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* WATTS' "Dictionary of Chemistry."

Russian Petroleum.—Though the oil springs of the region of "Eternal fire" in the neighbourhood of the Caspian Sea have been known for probably more than 2000 years, it is remarkable that it is only since the discovery of petroleum in America that the Russians have worked them to any great extent.

Mr. **Boverton Redwood**, in a valuable paper on the "Russian Petroleum Industry," gives the following figures showing the growth of this industry since 1801, when the attention of the Russian Government was first directed to the subject:—

Output of Crude Petroleum.

Year	Output	Year	Output
Year 1840	3,565 tons	Year 1878	320,000 tons
„ 1872	24,800 „	„ 1879	370,000 „
„ 1873	64,000 „	„ 1880	420,000 „
„ 1874	78,000 „	„ 1881	490,000 „
„ 1875	94,000 „	„ 1882	680,000 „
„ 1876	194,000 „	„ 1883	800,000 „
„ 1877	242,000 „	„ 1884	1,130,000 „

Mr. Redwood describes the refining of the oil as follows:— "The crude oil is, in the first instance, conducted from the well through wooden channels to ponds or lakes, where it deposits the sand held in suspension, and it is then pumped into storage tanks prior to being piped to the refineries. At present there are seven pipe lines, capable of delivering at the refineries more than 700 millions of gallons annually. The stills are worked on the principle of continuous distillation, a stream of oil flowing through the entire series of not more than twenty-five stills. This method of distillation is peculiarly suited for Russian petroleum, since from such oil only a comparatively small percentage of kerosene is obtained, and the residuum flowing from the stills is almost as fluid as the crude oil. The products of distillation are first separated into three fractions, termed respectively—

Benzene S.G. 0·754
Gasolene „ 0·787
Kerosene „ 0·820 to 0·822

"The kerosene distillate is pumped into lead-lined iron tanks, termed agitators, of the capacity of 57,000 gallons, where it is treated with about 1½ per cent. of sulphuric acid. The acid is forced up to the top of these tanks, which are above ground, by air pressure, and is distributed through perforated coils of leaden pipes, so that it falls through the oil in fine streams. The oil and acid are then subjected to agitation by introducing a blast of air at the base of the tank. After this treatment, the acid is allowed to subside, and the oil is drawn off into a similar sized iron tank, without lead lining, standing at a lower level. In this tank, which is furnished with a similar method of agitation, the oil is treated with a solution of caustic soda, and is afterwards washed. Fresh water being scarce, the washing is performed by sea-water brought by an aqueduct from the Caspian Sea. The kerosene is run from the washing agitators into settling tanks, where it deposits water, and thence is pumped into storage tanks preparatory to being placed in the tank steamers for conveyance to the mouth of the Volga. The whole process of treatment of the distillate occupies fifteen or sixteen hours.

"The residue in the stills, after the kerosene has been distilled off, has a specific gravity of about 0·903, and is known by the Russian name of *astatki*, or by the Tartar name of *masut*. It is usually stored in large excavated tanks lined with masonry. From the *astatki* about 30 per cent. of lubricating oil is obtained by distillation, and about 15 per cent. of "solar" oil (specific gravity about 0·860, and flashing point about 220° F., closed test). The remainder is used as fuel."

*Comparison of Russian and American Petroleum.**

	Russian.				American.	
	Baku No. 1.	No. 2.	No. 3.	Ordinary Kerosene Baku.	Austral&ouml;l.	Ordinary.
Specific gravity ...	At 19° C. 0·802	At 14° C. 0·822	At 16·5° C. 0·842	At 14° C. 0·822	At 14° C. 0·788	At 16° C. 0·795
Percentage of distillate at 200° C.	65·6	33·4	—	31·2	37·8	25·0
Ditto at 280° C. ...	92·6	80·4	76·4	80·4	85·0	52·8
Specific gravity of distillate at 200° C.	At 20° C. 0·790	At 20° C. 0·787	—	At 18° C. 0·789	At 20° C. 0·766	At 19° C. 0·753
Ditto at 280° C. ...	At 19° C. 0·822	At 20° C. 0·831	At 19° C. 0·835	At 18° C. 0·832	At 20° C. 0·785	At 19° C. 0·786
Percentage of distillate at 100°......	—	—	—	—	—	—
From 100° to 120°	0·1 (Boiling point)	(Boiling point)	—	(Boiling point)	—	(Boiling point)
" 120° to 140°	0·6	0·8	—	0·8	—	0·8
" 140° to 160°	24·9	7·8	—	8·8	0·2 (Boiling point)	6·6
" 160° to 180°	48·0	21·2	—	20·8	3·0	16·0
" 180° to 200°	65·5	33·4	(Boiling point)	31·2	27·8	25·0
" 200° to 220°	76·6	45·0	13·6	44·0	48·0	30·2
" 220° to 240°	84·2	57·8	38·8 (Yellow)	56·2	63·8	34·8
" 240° to 260°	88·8 (Colourless)	70·0 (Colourless)	62·0 (Yellow)	69·6 (Colourless)	75·2	44·2 (Yellowish)
" 260° to 280°	92·6 (Colourless)	80·4 (Yellowish)	76·4 (Yellow)	80·4 (Yellowish)	85·0	52·8 (Yellow)
Residue...............	2·6 (Golden yellow)	15·6 (Golden yellow)	20·9 (Brown)	14·8 (Golden yellow)	11·8	41·8 (Brown)
Loss	4·8	3·0	3·3	4·8	3·2	5·4
Evaporating point	25·5°	28°	Not determined	Not determined	52·2°	28·5°

Of the three Baku samples numbered 1, 2, and 3, No. 1 is prepared only in small quantities, No. 2 is the ordinary commercial variety, and No. 3 is a heavy kerosene manufactured for Persian consumption. The table shows that the hydrocarbons in the Russian oils are more volatile than those in the American. From 70 to 75 per cent. of the American and from 25 to 30 per cent. of Caucasian petroleum is available for use for illuminating purposes. It is said that some unscrupulous Baku refiners mix with the kerosene, or burning oil, a portion of crude oil, benzine, gasoline, or lubricating oils, diminishing the lighting value and increasing the risks of explosion.

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* WATTS' "Dict. of Chemistry," supp. 3, pt. ii. p. 1510.

Petroleum as Fuel.—The advantages claimed for petroleum as a steam fuel are cheapness as a generator, economy of space for storage, and greater simplicity in the arrangement of the furnace. In a country poor in coal measures, and where steam fuel has consequently to be imported, the value of a large supply of native petroleum is of the highest possible kind. Recent trials have proved that the mineral oils can be burnt advantageously for stationary, marine, and locomotive boilers, as well as in the reduction of iron ore, and in stoves for family use. Efforts have been unceasingly made to perfect the arrangements for burning, and for the safety of the use of the oil-fuel. One improved plan has been suggested by M. DE BERGUE, of Paris, which may lead to important results. If a jet of steam be allowed to enter a tube, the other end being open to the atmosphere, a current of air will be drawn through, and may be projected with the steam on the oil at a pressure corresponding to that of the steam, making a powerful air as well as steam blast, and the furnace would act on the same principle as the cupola furnace for melting iron. To forge iron, smelt ores, and melt glass, superheated steam is used, but for ordinary furnaces the latter is not necessary.* Siemens' regenerative furnace and Eames' (American) furnace are said to give satisfaction for smelting operations.

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* Speaking on this subject before the Society of Arts (Nov. 19, 1884), Sir F. ABEL said: "A successful experiment has been made at the Forth

The products noticed below rank high among the numerous varieties of mineral oil now in the market. Their properties are described in accordance with the results obtained by Mr. W. B. TEGETMEIER, who has devoted much time to the examination of the mineral oils:—

Albertite Oil.—From "albertite," a lustrous black

Bridge works in working the furnace of one of the air-compressing engines with the residual products of the distillation of shale oil obtained at one of the largest Scotch mineral-oil works. This butter-like material, liquefiable by heat, for which no use previously was known, and which cannot be ignited by the application of flame in the usual way, is allowed to flow through a superheating apparatus, and is thence carried into the furnace by a powerful jet of superheated steam. The force of the jet draws a powerful current of air into the centre of the flame produced by burning the mixtures of vapour and minutely divided liquid, and the result is said to be an almost perfect combustion of the fuel, with total absence of smoke, and of solid residue in the furnace. Hence it is probable that the residual products of British mineral-oil works may be utilized with advantage as substitutes for coal, as the cost is said to be even less than that of cheap coal. But far more important results in this direction have been obtained in Southern Russia during the last few years. The residual, or 'heavy,' oil which remains after the extraction of the illuminating and lubricating oils from the petroleum is already used as fuel on upwards of 300 steamers upon the Caspian Sea and Volga, and by the locomotives on the Trans-Caucasian and Trans-Caspian Railways. Its use is also extending to other railways in South-east Russia, and to manufactories in Moscow, where it is replacing English coal. Mr. URQUHART has shown that, weight for weight, it has 33 per cent. higher evaporative value than anthracite, and that, while 60 per cent. of efficiency is utilized with the latter, 75 per cent. is obtained with petroleum refuse. Russian gun-boats on the Caspian have for several years been worked by this liquid fuel, and its use is contemplated also for the Black Sea fleet. It is hardly likely in this country to compete with coal for locomotive purposes generally, but the comparative ease with which its perfect combustion is now insured appears to render it especially suitable for employment in underground railways, while its use in steamers cannot fail to be attended with important advantage in many special services."

mineral found in New Brunswick. A sample was shown in the Colonial Department of the International Exhibition of 1862, but the oil has not appeared in the English market.

Prop. Odour very slight; illuminating power high; boiling point, 338° F., or 126° above that of water.

Apyroetic Oil.—*Syn.* NON-EXPLOSIVE OIL.—A burning oil, introduced by F. TALL, of Hull, and prepared from American petroleum.

Prop. Slightly coloured; perfectly limpid; odour slight, but not perceivable during combustion. The most remarkable property of this oil is that, in spite of its limpidity, the point at which it gives off inflammable vapour is 180° F., or 80° above the requirements of the Petroleum Act (*open test*).

Belmontine Oil.—From Rangoon tar, or Burmese petroleum, by distillation; superheated steam being employed as the heating agent.

Prop. Colourless; odour not unpleasant; specific gravity, ·847, but, although so heavy, the oil is altogether free from viscosity, and will rise rapidly in a comparatively long wick; inflaming point, 134° F. (*open test*); burns with an exceedingly white light, and possesses a very high illuminating power.

The distillation of the Rangoon tar is carried on by Price's Candle Company under a patent. Besides the above lamp oil, several beautiful and useful products are obtained. At first there comes over a very volatile liquid, termed Sherwood oil, used as a detergent for removing grease from fabrics, cleaning gloves, &c.; then comes the Belmontine oil, already noticed; then two lubricating oils, the one light and the other heavy; and, last of all, when the temperature is considerably elevated, the beautiful white, translucent solid known as "Belmontine."

This last is a kind of paraffin, and is used for making ornamental candles.

Cazeline Oil.—An excellent burning oil, probably prepared from American petroleum, introduced by Cassell, Smith & Co., of London.

Prop. Bright, limpid, with scarcely a trace of colour; odour very slight, and quite free from any objectionable character; specific gravity, ·805; lowest point of ignition, 144° F. (*open test*); burns with a pure white light, free from smoke and smell.

Colzarine Oil.—A heavy hydrocarbon oil, adapted for burning in lamps constructed from the old "Moderators" and "Carcels," formerly so much used for the fat oils.

Prop. Limpid; quite inodorous; of a pale-amber colour; specific gravity, about ·838; temperature at which the vapour can be permanently ignited, 250° F. (*open test*). Tested in the altered moderator, it gives an intense white light, without smoke or smell. Compared with vegetable colza oil, its illuminating power is in the proportion of 3 to 2.

This oil is manufactured by Cassell, Smith & Co., under Martin's patent for the modification of mineral oils, to fit them for burning in lamps where "colza" and other vegetable and animal oils have been usually consumed. Similar oils are prepared by other firms.

The following table by A. H. ALLEN* shows roughly the differences existing in chemical constitution between petroleum products and the bodies of similar physical characters obtained by the distillation of shale :—

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* "Year Book of Pharmacy," 1880, 527. "Commercial Organic Analysis," ii. 26.

Product.	From Petroleum.	From Shale.
Naphtha.	At least 70 per cent. of heptane, C_7H_{16}, and other hydrocarbons of the marsh-gas or paraffin series, C_nH_{2n+2}. The remainder apparently olefines, C_nH_{2n}, with distinct traces of benzene, C_6H_6, and its homologues.	At least 60 or 70 per cent. of heptylene, C_7H_{14}, and other hydrocarbons of the olefiant gas or ethylene series, C_nH_{2n}. The remainder paraffins, C_nH_{2n+2}. No trace of benzene or its homologues.
Photogene, or burning oil.	55 to 80 per cent. of higher members of paraffin series, C_nH_{2n+2}. The remainder chiefly olefines.	60 to 65 per cent. of higher members of olefine series, C_nH_{2n}. The remainder paraffins, C_nH_{2n+2}.
Lubricating oil.	A large proportion of higher olefines, C_nH_{2n}, but less than in corresponding shale product.	Almost wholly higher olefines, the paraffins of similar high boiling point being solid. No naphthalene.
Wax.	Solid paraffins, C_nH_{2n+2}.	Solid paraffins, C_nH_{2n+2}.

Mr. Allen, therefore, concludes that the naphthas from petroleum and shale are not chemically identical, but that, probably, while petroleum spirit consists chiefly of heptane, C_7H_{16}, and other members of the marsh-gas or paraffin series of hydrocarbons, shale naphtha contains a very large proportion of the olefine or ethylene series, heptylene, C_7H_{14}, being one of its leading constituents.

*Specific Gravity of Paraffins.**

	Melting Point. C.	Specific Gravity		
		At 17° C.	At 55° C.	60°-65° C.
Solar oil and paraffin ...	38°	0·872	0·779	—
Secunda paraffin	43°	0·883	0·788	—
,, press-paraffin...	43°	0·889	0·785	—
,, paraffin	46°	0·887	—	0·781
Prima press-paraffin......	47°	0·900	—	0·775
,, ,, ...	51°	0·908	—	0·775
Hard paraffin	56°	0·912	—	0·777

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* Albrecht, "Dingl. Polyt. J." ccx

Albrecht also observed that solutions of paraffin in mineral oils have lower specific gravities than either the oils or the paraffins separately, so that, in selecting for technical purposes lubricating oils of as great a density as possible, it is best to take oils from which the greater portion of the solid paraffin has crystallized out.

Ozokerit.—*Syn.* Fossil wax, Mineral wax.—This substance, which has recently been utilized as a source of paraffin and the mineral hydrocarbon oils, is found in various localities in the Tertiary strata, mostly occurring in, or in close proximity to, the coal measures. But, although extensive deposits of it are to be met with in Galicia, on the slopes of the Carpathian Mountains, and in the island of Tcheleken in the Caspian Sea, it is by no means an abundant body. In the Austrian empire there are many large manufactories for its conversion into paraffin and the mineral oils. In our country there is, we believe, only one—that of Messrs. Field. Ozokerit is usually met with as a compact brown substance, occasionally yellow, sometimes black. It melts at a temperature varying from 60° to 80° C.

Neft-gil is the name of a substance very similar to ozokerit, and is found on the island of Swätoi-Ostrow in the Caspian Sea. According to Rossmässler, neft-gil is treated in the following manner:—15 cwt. of the crude material is put into iron stills provided with a leaden worm, and submitted to fractional distillation. It yields 68 per cent. of distillate, consisting of 8 per cent. of oil and 60 per cent. of crude paraffin. The oil obtained is yellow, opalescent, and possesses an ethereal odour, and a sp. gr. of 0·75 to 0·81. Each distillation yields a quantity of a light oil, boiling below 100° C., which is used for the purpose of purifying the paraffin. The crude paraffin obtained by the first distillation is tolerably pure, has a yellow colour, and can at once be treated by the hydraulic press and centrifugal machine.

The oil expressed in these operations is again submitted to fractional distillation in order to obtain more paraffin. The pressed paraffin is melted and treated at 170° to 180° C. with sulphuric acid, which is next neutralized by means of lime, and the paraffin again rapidly distilled, then again submitted to strong pressure, and the material obtained treated with 25 per cent. of the light oil; then again melted, again pressed, and finally treated with steam for the purpose of eliminating the last trace of oil. The substance obtained by this treatment is a perfectly pure, colourless material, free from smell, transparent, and so hard as to afford in large blocks almost a metallic sound when struck. Its fusing point is about 63° C.

Vaseline.—*Syn.* SAXOLEUM PURIFICATUM, PETROLEUM JELLY.—The residual matters after the distillation of petroleum, purified by charcoal, have been introduced into commerce under the name of "vaseline" by the Chesebrough Manufacturing Co. According to Moss, its composition is—

Hydrocarbons (paraffin?) . . .	97·54
Moisture	0·50
Ash	0·05
	98·09

It melts at 37° C., and at 55° C. has a sp. gr. of 0·840. It is of a pale-yellow colour, translucent, slightly fluorescent, semi-solid, insoluble in water, slightly soluble in alcohol, freely soluble in ether, and unaffected by hydrochloric acid and solution of potash. The process of manufacture is as follows:—The crude oil is highly concentrated, the lighter hydrocarbons being driven off by simple heat, without distillation; the product is then carefully and repeatedly filtered through bone-black or animal charcoal, just as syrup is filtered in sugar refining, and the result is either pale yellow or pure white, according to the length of the treatment. It is extensively used instead of lard in the preparation of ointments, a purpose for which its freedom from smell, its negative properties, and its unalterable qualities when exposed to the air, render it very suitable. It has also been successfully used for lubricating surgical instruments and as a basis for pomades.

In Germany the following methods of production are in use: *—A. 1°. The material, either crude ozokerit or petroleum residue, is heated by steam to about 30° C. (86° F.), mixed at this temperature with 10 per cent. of its weight of sulphuric acid of 60° B., stirred for half an hour, and then allowed to stand at rest so that the carbonized portions may settle. 2°. When clear, the oil is washed with an aqueous solution of potassium bichromate, whereby any remaining excess of sulphuric acid is at the same time removed. 3°. The residue from the acid treatment is mixed with lime, neutralized, and disposed of to manure factories. 4°. The clear oil from the second step of the process, after being washed, is heated by steam to 80° C. (176° F.), mixed with 10 per cent. of its weight of granular *spodium*,† and then allowed to rest to permit the spodium to settle. 5°. After the latter is separated, the liquid portion is filtered through filters heated by steam. 6°. The residuary magma of spodium is subjected to hydraulic pressure, the expressed oil filtered, and the solid residue again used in the next operation, a sufficient quantity of fresh spodium being added to make up for any loss or waste.

B. 1°. The petroleum residue, or the natural ozokerit containing vaseline, is rendered fluid, and the liquid, after the separation of all extraneous matters, is passed through a series of charcoal filters, such as are used in sugar refineries. After the liquid has passed twelve or fifteen of these cylindrical filters, its original brownish-black colour has become yellowish. To render it colourless and limpid as water, double the number of filters are required. The specific gravity diminishes as the colour is removed, but, when it has become colourless, the specific gravity remains stationary, no matter how long the filtration may be continued. 2°. After it has been thus freed from all bituminous matters, it is transferred to the "duplicator," where it is brought into direct contact with superheated steam, and the temperature is allowed to rise to 250° C. (482° F.). Samples which are taken from the boiler from time to time show that no further alterations can be observed in the product after it has been at this temperature for a few hours. 3°. The finished vaseline, amounting to 25 or 30 per cent. of the raw material, is finally filtered and filled into cans for shipping. A great drawback in this method is the rapid exhaustion of the animal charcoal, which can decolorize only a small percentage of its own weight of crude vaseline. It is therefore necessary to have extensive facilities for extracting the portion retained by the charcoal, and to regenerate the latter, which may be done by superheated steam at a temperature of 400° to 500° C. (752° to 932° F.). It is for this reason that most factories use sulphuric acid for purifying, by means of which the material may be brought to the colour of beer, so that only one-third as much charcoal is required for final decolorization as in the other process. It is, however, almost impossible to get rid of the last traces of the chemicals employed.*

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* "J. Soc. Chem. Ind." 1882, 97. † Metallic soot from furnaces.

Russian vaseline differs from the European article in its consistency, and in this respect closely resembles the American product. It resembles the latter also in its softness and tenacity, whether it has been previously melted and cooled without stirring or not. American vaseline dissolves to a clear solution on warming in ether and petroleum benzine, and remains so after cooling, or is at most slightly turbid. European sorts, however, form a thick solution with the above solvent, and deposit a considerable amount of sediment on cooling. The Russian vaseline occupies in this respect an intermediate position. It dissolves completely and gives a clear solution, but becomes turbid on cooling. On account of its comparative cheapness, Russian vaseline appears to offer considerable advantages over other kinds.*

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* "Pharm. Central." 1881, 42.

Storage of Petroleum.—The following are the best means of securing the safe storage of petroleum:—

1°. The barrels or cases to be kept in warehouses of one storey only, built of incombustible materials.

2°. The oil to be kept in metallic tanks.

3°. A large storage tank made of masonry, filled with water, in which can be placed, mouth downwards, a vessel like a gas-holder, containing the petroleum, which is to float on water within the inverted vessel.

4°. Attaching weights to the ordinary barrels and sinking them in water.

M. Pelzer points out that if a ship laden with petroleum takes fire in a crowded port it is worse than useless to scuttle her, because the water rushing in displaces the oil, and thus causes it to float on the surface of the water, instead of being confined to the burning ship.

Notes on the Construction of Petroleum Lamps.—The Metropolitan Board of Works have recently issued the following instructions as to the construction and management of ordinary mineral-oil lamps:—

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* "Biel. Pharm. Ztschr. Russl." 21, 41; "J. Soc. Chem. Ind." 1882, 98.

A. Lamps.

1. That portion of the wick which is in the oil reservoir should be enclosed in a tube of thin sheet-metal, open at the bottom, or in a cylinder of fine wire gauze, such as is used in miners' safety-lamps (28 meshes to the inch).
2. The oil reservoir should be of metal, rather than of china or glass.
3. The oil reservoir should have no feeding-place or opening other than the opening into which the upper part of the lamp is screwed.
4. Every lamp should have a proper extinguishing apparatus.
5. Every lamp should have a broad and heavy base.

B. Wicks.

1. Should be soft, and not tightly plaited.
2. Should be dried at the fire before being put into lamps.
3. Should be only just long enough to reach the bottom of the oil reservoir.
4. Should be so wide that they quite fill the wick-holder without having to be squeezed into it.
5. Should be soaked with oil before being lit.

C. Management.

1. The reservoir should be quite filled with oil every time before using the lamp.
2. The lamp should be kept thoroughly clean. All oil should be carefully wiped off, and all charred wick and dirt be removed, before lighting.
3. When the lamp is lit, the wick should be first turned down and then slowly raised.
4. Lamps which have no extinguishing apparatus should

be put out as follows:—The wick should be turned down until there is only a small flickering flame, and a sharp puff of breath should then be sent *across* the top of the chimney, but not *down* it.

5. Cans or bottles used for oil should be free from water and dirt, and should be kept thoroughly closed.

CHAPTER VIII.

PURIFICATION, BLEACHING, AND REFINING OF OILS, &c.

SEVERAL methods are adopted for refining or purifying the fixed oils, among which are the following :—

1. The oil is violently agitated along with 1½ to 2 per cent. of concentrated sulphuric acid, when it assumes a greenish colour, and, after about a fortnight's repose, deposits much colouring matter, becomes paler, and burns with greater brilliancy, particularly if well washed with steam or hot water, and clarified by subsequent repose or by filtration. This answers well for most of the recently expressed vegetable oils. It also greatly improves most of the fish oils.

2. A modification of the above method is to well mix the acid with the oil, then to blow steam through the mixture for some time, and afterwards to proceed as described.

3. **Fish Oil** (**Whale, Seal, &c.**) is purified by—

a. Violently agitating it with boiling water or steam, by placing it in a deep vessel with perforated bottom, through which high-pressure steam is forced for some time; it is afterwards clarified by repose, and filtered through coarse charcoal.

b. The oil is violently agitated with a boiling-hot and strong solution of oak bark, to remove albumen and gelatin, and next with high-pressure steam and hot water; it is, lastly, dried and filtered.

c. The oil, gently heated, is stirred for some time with about 1 per cent. of good chloride of lime, previously made into a milk by trituration with water; about 1½ per cent. of oil of vitriol, diluted with 20 times its weight of water, is then added, and the agitation renewed and maintained for at least two hours; it is, lastly, well washed with steam or hot water.

d. Mr. DAVIDSON treats the oil first with a strong solution of tan, next with water and chloride of lime, then with dilute sulphuric acid, and, lastly, with hot water.

e. Mr. DUNN's method, which is very effective, and admirable on account of its simplicity, is to heat the oil by steam to from 180° to 200° F., and then to force a current of air of corresponding temperature through it, under a flue or chimney, until it is sufficiently bleached and deodorized; it is, lastly, either at once filtered or is previously washed with steam or hot water.

f. Another method, formerly very generally adopted and still in use, is to violently agitate the oil for some time with very strong brine, or with a mixed solution of blue vitriol and common salt, and then either to allow it to clarify by repose or to filter it through freshly burnt charcoal.

4. **Almond, Castor, Linseed, Nut, Olive, Rape,** and some other vegetable oils are readily bleached by either of the following processes:—

a. Exposure in glass bottles to the sun's rays, on the leads or roofs of houses, or in any other suitable position, open to the south-east and south. This is the method employed by druggists and oilmen to whiten their castor and linseed oils. Fourteen to twenty-one days' exposure to the sun in clear weather during summer is usually sufficient for castor oil when contained in 2- to 4-quart pale-green glass bottles (preferably the former), and covered with white gallipots inverted over them. The oil is filtered before exposing it to the light, as, if only in a slight degree opaque, it does not bleach well. Almond and olive oil are, when thus treated, apt to acquire a slight sulphurous smell; but this may be removed by filtration through a little animal charcoal, or, still better, by washing the oil with hot water.

b. Another method employed to decolour these oils is to heat them in a wooden, tinned, or well-glazed earthen vessel along with some dry "filtering powder" (1 to 2 lb. per gall.), with agitation for some time, and, lastly, to filter them in the usual manner through an oil-bag. In this way the West-end perfumers prepare their "white almond oil" (OLEUM AMYGDALÆ ALBUM) and their "white olive oil" (OLEUM OLIVÆ ALBUM). Formerly, freshly burnt animal charcoal was used for this purpose, and is still so employed by some houses.

5. Mr. BANCROFT refines **Oils for Machinery and Lubricating Purposes** generally, by agitating them with a lye of caustic soda of the sp. gr. 1·2. A sufficient quantity is known to have been added when, after repose, a portion begins to settle down clear at the bottom. About 4 to 8 per cent. is commonly required for lard oil and olive oil. After twenty-four hours' repose, the clear supernatant oil is decanted from the soapy sediment, and filtered.

6. Not only the oils above referred to, but all other oils and fats, may be rendered perfectly colourless by the use of a little chromic acid; or by a mixture of a solution of bichromate of potassa and sufficient sulphuric, hydrochloric, or nitric acid to seize on all the alkali, and thus liberate the chromic acid.

7. **Palm Oil** and **Cocoa-nut Oil** are generally refined and bleached by either chromic acid, or chlorine, or by heat:—

a. The "butyraceous oil" is liquefied by heat in a wooden vessel, and 7 to 9 per cent. of good chloride of lime, previously made into a smooth cream with water, is added, and the whole assiduously stirred until the ingredients appear united; the mixture is then allowed to cool, and is next cut up into small lumps, which are exposed to a free current of air for two, three, or even four weeks; these are melted in a wooden vessel heated by high-pressure steam circulating through leaden pipes, or in a cast-iron boiler lined with lead, and an equal weight of oil of vitriol (diluted with about 20 times its weight of water) is poured in, and the whole gently boiled until the oil is decoloured and runs clear; the fire is then moderated, and the whole allowed to settle; lastly, the fire is removed, and the oil is left to cool very slowly.

b. The process with chromic acid has been already noticed (No. 6, p. 194), but is more fully explained below (*b*, p. 196).

c. The oil, heated to the temperature of about 250° F., is exposed to the action of high-pressure steam, which is continuously "blown" through it for ten or twelve hours, or even longer. The process is greatly facilitated by the introduction of some chromic acid.

8. Mr. Watts' methods of purifying fats and oils are very effective, more especially for those intended for illumination. They are as follow :—

a. For **Fish Oils.**—Each ton is boiled for half an hour with caustic soda, ½ lb., previously made into a weak lye with water; or steam is blown through the mixture for a like period; oil of vitriol, ½ lb., diluted with 6 times its weight of water, is next added, the whole again boiled for fifteen minutes, and allowed to settle for an hour or longer, when the clear oil is run off from the water and sediment into the bleaching tubs; here solution of bichromate of potash, 4 lb., in oil of vitriol, 2 lb., previously diluted with water, q. s., together with a little nitric acid and some oxalic acid, are added, and after thorough admixture of the whole, by blowing steam through it, strong nitric acid, 1 lb., diluted with water, 1 quart, is poured in, and the boiling continued for half an hour longer; a small quantity of naphtha or rectified spirit of turpentine is then mixed in, and the oil is, finally, well washed with hot water, and left to settle.

b. For **Palm Oil.**—The oil is melted by the heat of steam, and, after it has settled and cooled down to about 130° F., is carefully decanted from the water and sediment into the steaming-tubs; here a mixture of a saturated solution of bichromate of potash, 25 lb., and oil of vitriol, 8 or 9 lb. is added, and, after thorough admixture, hydrochloric acid, 50 lb., is poured in; the whole is then constantly stirred until it acquires a uniform greenish colour, or is sufficiently decoloured, a little more of the bleaching materials being added if the latter is not the case, after which it is allowed to repose for half an hour to settle; it is next run into a wooden vat, where it is washed, &c., as before.

c. For **Vegetable Oils.**—These are treated with a solution of chromic acid, or with a solution of bichromate of potash, and a mineral acid, as noticed under No. 6, p. 194. For colza, linseed, mustard, nut, and rape oils, a little hydrochloric acid is added; but for almond, castor, olive and poppy oils, no such addition (at least in excess) is required.

9. **Rancid Oils** and **Fats** are recovered by boiling them for about fifteen minutes with a little water and calcined magnesia; or by filtering them through freshly burnt charcoal.

In reference to the above processes, it may be useful to remark that chlorine, the common bleacher and deodorizer of other substances, cannot be well employed directly in the purification of oils, as certain chemical reactions occur when these substances are brought together, which increase the colour instead of removing it, and are often otherwise injurious. The same remarks apply to the use of the "chlorides," which frequently fails in unskilful hands, and is, indeed, of questionable utility, except, perhaps, in the case of palm oil. Even charcoal exerts little of its usual energy on the oils, and, whilst it removes or lessens their offensive odour, sometimes increases their colour. The addition of 1 or 2 per cent. of very pure and recently rectified naphtha or oil of turpentine (camphine) to lamp oil is a real improvement, since it increases its combustibility and its illuminative power.

Oils for Medical Purposes, as castor oil, cod-liver oil, &c.,. must not be subjected to any process beyond mere clarification by subsidence, filtration through Canton flannel or porous paper, or, at the utmost, washing with warm water, as otherwise their active and valuablo properties, if not wholly removed, will be considerably lessened.

Rancid Castor Oil.[*]—Heat 100 lb. to 80° F. in a boiler. Then a mixture of ½ lb. of alcohol (96 per cent.) and ½ lb. sulphuric acid is added and crutched in. The mixture is allowed to settle, and the oil is drawn off from the impurities which have settled at the bottom. The oil is again washed by boiling it uninterruptedly with water for half an hour. After resting, the oil is again drawn off. Rancid oil treated in this way is fit for use in the manufacture of transparent soap.

Purifying Fatty Oils.—Oils which hold in solution fatty acids or other substances may be easily purified by the process of Viallis Frères, by filtering through sawdust impregnated[†] with a solution of soda. Barrels sawn in two can be used, the bottoms of which are pierced with holes. In the bottom is placed a layer of flannel, on which the sawdust is placed to the depth of 6 or 8 inches. If a colourless oil is desired, a thin layer of animal black is placed upon the sawdust. By placing two or three of these vats above each other, a perfectly pure oil is obtained.

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[*] "American Druggist."

[†] Corps Gras Industriels.

Tallow.—The following is recommended as a good process for bleaching tallow *:—About 50 lb. of caustic soda lye are placed in a clean boiler and the steam turned on. Salt is then added to the lye until it shows 25° to 28° B. The fat—300 lb.—is now placed in the boiler and heated to boiling. It is allowed to boil up 1 to 2 inches at most, and then left for three to five hours to clarify. At the end of this time the upper saponified layer is ladled off; the purer tallow is removed and passed through a hair sieve into a clean vessel until the lower saponified layer is reached. The residue in the boiler, consisting of saponified fat and lye, together with the upper layer, may be used in the preparation of curd soap. The boiler having been thoroughly cleansed, about 30 lb. to 35 lb. of water, with ¾ lb. to 1 lb. of alum, are placed therein and heated to boiling. To this solution the fat is added, and the whole is boiled for about fifteen minutes, till the filth has disappeared from the fat. Transferred after this to another vessel, it is left to itself for three to five hours. The pure fat obtained from this is again placed in the boiler and heated to the temperature of 170° to 200° C. In this last operation the fat becomes snow-white and fit for use. The steam must be turned off as soon as the slightest trace of vapour of disagreeable odour is thrown off, whether the temperature be 150° or 170° C., otherwise the fat will again turn dark. Freshly rendered, sweet fat is most readily bleached, and may be heated quite high. Still the fat used should not be too fresh, or there will be risk of saponifying the whole of the 300 lb. without leaving any to bleach. Tallow which has been treated in this way, when used in toilet soaps, gives them a white colour and agreeable odour. It is also well adapted for candle-making, as it becomes exceedingly hard.

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* "Oil Trade Review," Oct. 1884.

Refining Wax.—Crude wax, especially that imported, is generally loaded with dirt, bees, and other foreign matter. It is freed from these by the operation of refining. This is done by melting the wax along with about 4 or 5 per cent. of water in a bright copper or stoneware boiler, preferably heated by steam, and, after the whole is perfectly liquid and has boiled for some minutes, the heat is withdrawn, and a little oil of vitriol is dropped over its surface in the proportion of 5 or 6 fl. oz. to every hundredweight of wax. This operation should be performed carefully, otherwise the melted wax froths up and boils over the sides of the pan. The melted wax is next covered over, and left for some hours to settle, or until it becomes sufficiently cool to be drawn off for "moulding." It is then very gently skimmed with a hot ladle, baled or decanted into hot tin "jacks," and by means of these poured into basins, where it is left to cool. Great care must be taken not to disturb the sediment. When no more clear wax can be drawn off, the remainder in the melting-pan is allowed to cool, and the cake, or "foot" as it is called, is taken out, and the impurities, mostly bees, scraped from its under surface. The scraped cake is usually reserved for a second operation; but, if required, it may be at once re-melted and strained through canvas into a mould.

Much of the foreign wax has a pale, dirty colour, which renders it, no matter how pure, objectionable to the retail purchaser. Such wax undergoes the process of "colouring" as well as "refining." A small quantity of the best rol annotta, cut into slices ($\frac{1}{4}$ lb., more or less, to each hundredweight of wax, depending on the degree of paleness of the latter), is put into a clean boiler with about a gallon of water, and boiled for some time, or until it is perfectly dissolved, when a few ladlefuls of the melted wax are added, and the boiling continued until the wax has taken up all the colour, or until the water is mostly evaporated. The portion of wax thus treated has now a deep-orange colour, and is added in quantity as required to the remainder of the melted wax in the larger boiler until the proper shade of colour is produced when cold, the whole being well mixed, and a sample of it cooled now and then to ascertain when enough has been added. The copper is next brought to a boil, and treated with oil of vitriol, &c., as before. Some persons add palm oil (bright) to the wax until it gets sufficient colour, but this plan is objectionable from the quantity required for the purpose being often so large as to injure the quality of the product, besides which the colour produced is inferior and less transparent and permanent than that given by annotta.

Another method of refining crude wax, producing a very bright article, is to melt it in a large earthen or stoneware vessel heated by steam, or a salt-water bath, then to cautiously add to it about 1 per cent. of concentrated nitric acid, and to continue the boiling until nitrous fumes cease to be evolved, after which the whole is allowed to settle and is treated as before.

The great art in the above process is to produce a wax which shall at once be "bright," or semi-translucent in thin pieces, and good-coloured. The former is best ensured by allowing the melted mass to settle well, and by carefully skimming and decanting the clear portion without disturbing the sediment. It should not be poured into the mould too warm, as, in that case, it is apt to "separate," and the resulting cakes become "streaky," or of different shades of colour. Again, it should be allowed to cool very slowly. When cooled rapidly, especially if a current of air fall upon its surface, it is apt to crack, and to form cakes full of fissures. Sometimes the cakes are polished with a stiff brush when quite cold and hard. It is absolutely necessary that the "jacks" or cans, ladles, and skimmers used in the above process be kept pretty hot, as, without this precaution, the wax cools and accumulates upon them in such quantity as to render them inconvenient, and often useless, without being constantly scraped out.

Refining Petroleum.—The following method is one of those practised in Canada:—

The charge, taken from the under-ground store tanks, is introduced into wrought-iron stills, of about 1600 gallons content. These stills are flat-bottomed and are provided with man-holes, through which the black pitchy residue is removed.

The distillation is effected by a fire placed underneath. The charge takes a week to work off; the distillate being collected in large wooden tubs, a small quantity of a thick greenish substance which separates is returned to the stills. The pitch-like residue is used for fuel for the next operation.

The liquid collected is mixed with 5 to 10 per cent. of sulphuric acid, and agitated by rotatory paddles at a steam heat for the purpose of bleaching it. After this is done, the bleached oil is washed with water, the last traces of acid are neutralized with potash, and it is finally deodorized with ammonia. The loss in distillation is about 30 per cent. The refined oil is packed in 40-gallon barrels made of oak, lined, to prevent leakage, with an elastic cement, resembling vulcanized india-rubber, the principal ingredients of which are glue and white lead.

According to H. VOHL,* petroleum may be purified from sulphur by treatment with acids and alkalis. The impurity is most easily detected by heating the petroleum with metallic sodium. If sulphur is present, the bright metal soon becomes covered with a yellow crust of sodium sulphide, which may be dissolved off by water, and tested. The quantity of sulphur may be estimated by distilling the petroleum over red-hot lime, and subsequently weighing the sulphur, as barium sulphate. In this way VOHL found different kinds of petroleum to yield from 0·300 to 3·114 per cent. of sulphuric acid.

The following process for refining petroleum has been patented by J. C. MEWBURN:—The crude oil is first divided into two portions, possessing distinct characteristics, called "primary oil" and "secondary oil." The average yield of the primary oil is about 35 per cent. The division is effected by mixing any quantity of the crude oil with commercial benzene, previously obtained from petroleum by distillation, using enough benzene to effect a complete separation. The mixture is placed in an open vessel, and the latter placed in a larger vessel. The benzene volatilizes and leaves the mixture, carrying with it the "primary oil," which drops into the larger outer vessel, the benzene itself passing off as vapour. After the benzene has all evaporated, it will be found that the crude petroleum has been divided, the inner vessel containing the "secondary oil" and the outer the "primary." If the latter is to be employed as an illuminant, no further treatment is necessary, but if it is to be used as a lubricant it is mixed with about 1 per cent. of amyl alcohol, and the mixture treated with ordinary (ethylic) alcohol, until it becomes milky or opalescent. The supernatant oil is drawn off, and the purified "primary oil" removed. The oil thus treated has a density of about 28° B. Only about 1 per cent. of each alcohol is usually needed to effect the removal of the small proportion of light hydrocarbons contained in the "primary oil." This treatment imparts to the oil greater wearing qualities as a lubricant. The "secondary oil" has a density of about 36° B.

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* "Dingl. Polyt. J." ccxvi. 47; WATTS' "Dict. of Chem." suppt. iii. pt. ii. p. 1511.

† Pat. 12498, 1884.

It is subjected to fractional distillation as follows:—The first distillate is naphtha, which is allowed to run until the temperature rises to about 120° F. The receiver is then changed, and the distillation continued until the temperature reaches 288° F. This second distillate is kerosene, or burning oil. The receiver is changed again, and the temperature raised to about 326° F. This third distillate is a heavy burning oil, which the author of the process calls "petro-sperm oil." The residuum in the still is a heavy oil, which makes a good lubricant.

100 parts of crude petroleum yield when thus treated:—

"Primary oil"	(31° B.)	35 parts
Naphtha	(65° B.)	3 "
Kerosene	(50° B.)	40 "
"Petro-sperm"	(36° B.)	6 "
Residuum	(27° B.)	16 "

No tar or waste products are obtained by this process.

The purification of the kerosene is effected by adding to 95 parts 5 parts of sulphuric acid. The resulting "sludge" is allowed to subside; the oil is then drawn off and agitated with a small quantity of alcohol, which mixes or combines with the small portion of acid remaining in the oil, and carries it to the bottom. The kerosene will now be clear, limpid, entirely free from fluorescence, and neutral to test. The "petro-sperm" may be purified in the same manner as the kerosene, and will stand a fire-test of 149° F. It contains no paraffin, and does not form a crust on the wick when burned. Like the kerosene, it is almost odourless. By first separating from the crude petroleum the "primary oil," the inventor claims the removal of the principal difficulties incident to petroleum distillation by former methods, making this portion a valuable illuminant and lubricant. The "secondary oil," on the other hand, becomes nearly as valuable as the entire quantity of crude petroleum, from which it is obtained, would ordinarily be, owing to the improvements in the products obtained therefrom, their quantity, the ease with which it can be fractionally distilled, and the absence of waste products.*

Crude Paraffin.—FORDRED† purifies crude paraffin by melting, leaving mechanical impurities to settle down, then transferring to smaller vessels to cool. The cakes are next warmed till they become kneadable, and are then washed with a solution of 10 parts of soft soap in 90 parts of water, and heated to about 38° C. Colouring matters and any oils that may be present are transferred by this treatment to the soap water, and the solid paraffin comes out purified and bleached.

Recovery of Paraffin or Stearin from Petroleum or other Oil.‡—Instead of separating the solid constituents of oils from the liquid ones by filtration or hydraulic pressure, the patentee proposes to effect the same object by spraying the oil upon a travelling blanket, which afterwards passes between pressing rollers; the oil is squeezed out, and the solid matters which are left on the blanket are removed from it by a scraper, and carried away by a travelling belt. The process is said to be rapid and continuous, but requires close attention to the temperature of the room and of the oil.

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* "J. Soc. Chem. Ind." 1885, 49. † "Monit. Scien." [3] iii. 826.

‡ Eng. Pat. 13579, Dec. 15, 1884; "J. Soc. Chem. Ind." 1885, 288.

Crude Resin Oil.[*]—The decolorization is effected by heating in an iron boiler over a clear fire until it has become quite fluid. It is then drawn off into a wooden vat, frequently stirred, and 10 lb. of concentrated sulphuric acid is added for every 100 lb. of oil. After being allowed to rest twelve to eighteen hours, the oil is drawn off and washed several times with hot water. When it is completely freed from acid, it is dark-yellow, and almost inodorous. In order to obtain a bright-yellow product, the oil is now mixed with 50 per cent. of water, 10 per cent. of soda ash, and 10 per cent. of slaked lime, and finally submitted to distillation.

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[*] G. Schwarz, "Seifen Siedzeit." 23, 271; "J. Chem. Ind." 1883, 481.

CHAPTER IX.

TESTING OILS.

I. PURITY.

(1) Fixed or Fatty Oils.

Oils vary greatly in value, and hence there exists a constant inducement to adulterate the more expensive ones with those of a similar character but of an inferior kind. Many methods have been proposed for detecting these frauds, the chief of which we now proceed to notice. At the outset, it must be borne in mind that genuine oils, like other natural productions, are subject to considerable variations, according to the time of year when obtained, the country in which produced, age, &c., and that no sharp line of demarcation exists between them such as we are familiar with in inorganic analyses. It is also desirable to remember that it is not always safe to take the recorded results of one operator for comparison with those obtained by another, so much depending, in these cases, on individual methods of manipulation and individual accuracy of observation. It should be an axiom never to decide upon a "rough" examination, but each test should always be employed in precisely the same manner, with careful attention to exact quantities of the reagents and definite quantities of the samples under examination. It has also been often pointed out, and cannot, indeed, be too strongly insisted on, that a given sample should not be pronounced adulterated without comparison, side by side, with a sample of known purity, unless the amount or kind of adulteration is more than ordinarily gross. The tests capable of general application may be classified as follows:—

I. **Physical Tests.**—1°. Odour; 2°. Specific gravity; 3°. Melting and solidifying points; 4°. Drying properties; 5°. Viscosity; 6°. Spectroscopic examination; 7°. Cohesion figures.

II. **Chemical Tests.**—A. *Qualitative.*—1°. Colour tests; 2°. Rise of temperature with sulphuric acid; 3°. Elaïdin test; 4°. Spontaneous combustion; 5°. Solubility in acetic acid.

B. *Quantitative.*—1°. Amount of free acidity, and action on copper; 2°. Saponification; 3°. Determination of oleic, stearic, and palmitic acids; 4°. KOETTSTORFER'S saponification equivalents; 5°. HÜBL'S iodine process; 6°. MILLS' bromine absorption process; 7°. REICHERT'S process.

Of the physical tests, the most useful are the specific gravity and the melting points of the solid fats and of the fixed fatty acids. Of the *qualitative* chemical tests, the colour tests, the temperature reaction with sulphuric acid, and the elaïdin test often give useful indications. Of the *quantitative* tests, the processes of saponification, determination of the free acidity, and the iodine or bromine methods, especially the latter, are generally valuable.

I. Physical Tests.

1°. **Odour.**—The method of applying this test is to heat a few drops of the oil under examination in a small porcelain basin, platinum capsule, silver spoon, or watch-glass. When sufficiently cool, rub some on the palm of the hand, and again smell. Carefully compare the odour evolved with that arising from a known pure sample of the same kind and quantity of the oil similarly treated. The odour of the two, when each is pure, is alike, and, after some experience, suggests the plant, fish, or animal from which the oil has been obtained. The presence of linseed, nut, rape, seal, train, or whale oil is thus readily detected, and the imperfections of the sample, even if pure, may become perceptible.

2°. **Specific Gravity.**—The first to apply this test appears to have been M. PENOT, who was of opinion that oils from the same plant, or animal, never deviated from one specific gravity by more than a few thousandths. Various plans have been employed for ascertaining this by the specific gravity bottle, and several forms of oleometer.*

M. LAURET has observed that the variations of the density of an oil from adulteration are rendered much more apparent when it is examined in a heated state. To render this discovery practically available, he plunges an "elaïometer," graduated for the given temperature, into a small tin cylinder nearly filled with the oil, and then places this in a vessel containing boiling water; as soon as the whole has acquired a uniform temperature, he observes the point on the scale of the instrument at which it floats. This point is for—

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* **Oleometer.**—*Syn.* ELAÏOMETER, ELÆOMETER, OIL-BALANCE.—A delicate areometer or hydrometer, so weighted and graduated as to adapt itself to the densities of the leading fixed oils. As the differences of the specific gravities of these substances are inconsiderable, to render it more susceptible the bulb of the instrument is proportionately large, and the tube or stem very narrow. The scale of the oleometer in general use (Gobby's) is divided into 50°, and it floats at 0° or zero in pure poppy oil, at 38° or 38·5° in pure almond oil, and at 50° in pure olive oil. The standard temperature of the instruments made in this country is now 60° F.; those made on the Continent, 54·5° F. The oil must therefore be brought to this normal temperature, before testing it, by plunging the glass cylinder containing it into either hot or cold water, as the case may be; or a correction of the observed density must be made. The last is done by deducting two from the indication of the instrument for each degree of the thermometer above the normal temperature of the instrument, and adding two for every degree below it. Thus: suppose the

Colza oil	0°
Fish oil	83
Poppy oil	124
Hemp-seed oil	136
Linseed oil	210*

The specific gravity of an oil, or of a melted fat, is ascertained with great ease and accuracy by the specific-gravity bottle. To the student the following hints as to the manipulation of the melted fat of butter, extracted from "The Analysis and Adulteration of Foods," by Dr. J. **Bell**, part ii. p. 55, will prove useful:—"The fat is first separated from the water, curd, and salt by heating the butter in a glass beaker on a water-bath at about 150° F. (65·5° C.), and filtering to remove any particles of curd or salt it may con-

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temperature of the oil at the time of the experiment is 60° F., and the oleometer indicates 61°; then—

60·0° Actual temperature
54·5 Normal temperature
5·5 Difference

Indication of the oleometer	61·0°
The difference 5·5 × 2 =	11·0
Real density	50·0

* Mr. **Estcourt**[1] obtains very satisfactory results at high temperatures by using a hydrostatic balance, made by G. **Westphal**, of Celle, Hanover. The bulb, or plummet, suspended from the balance, is immersed in the test-tube (1¼ inch by 5) containing the melted fat, or oil. The desired temperature is obtained by placing the test-tube in a paraffin-bath. The latter is heated by an outer water-bath, and, when it arrives at a constant temperature (206°–208° F.), the weights on the arm of the balance are exactly adjusted, and the specific gravity of the oil under examination may be read off. A sketch of this apparatus, by Mr. J. **Carter Bell**, appears in the "Chemical News," 1878, 267.

[1] "Chemical News," 1876, 255.

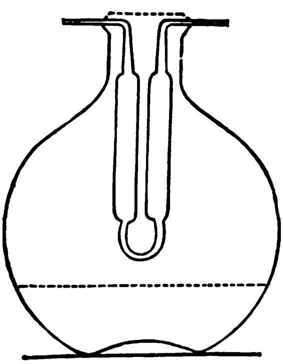
tain. The separation should be conducted as quickly and at as low a temperature as possible. The specific gravity of the perfectly clear and dry fat is then taken at the temperature of 100° F. (37·7° C.). For this purpose an ordinary specific-gravity bottle" (of which, of course, the accuracy has been tested by the analyst himself) "of a pear shape is used, into which a sensitive thermometer can be inserted, the bulb of which extends nearly the whole depth of the bottle. The fat is introduced at about 115° F., and gradually brought down to 100° F., when the bottle should be quickly filled from the residue of the fat, also cooled to 100° F. (37·7° C.), care being taken to push the glass stopper home, otherwise an excessive gravity will be obtained. It has been recommended to adjust the temperature of the fat in the bottle by placing it in water kept at 100° F.; but we have found this an unnecessary precaution, as, *where the requisite care is taken*, the first mode gives perfectly reliable results."

If a bottle adjusted to contain 1000 grs. of water at 60° F. (15·5° C.) is employed, to obtain the true specific gravity of the fat, the weight obtained must be divided by the weight of water which the bottle will contain at 100° F., and the result multiplied by 1000. If a bottle were used which contains 50 gms. of distilled water at 100° F., and the weight of the fat at the same temperature was found to be 45·58 gms., then the specific gravity of the fat would be $\frac{45·58}{50} \times 1000 = 911·6$, water being 1000.

When the density of the given sample has been taken, and the name of the oil used to adulterate it is known, the quantity of the latter present may be approximately determined from the specific gravities by the common method of alligation.

Mr. L. ARCHBUTT adopts the following plan for taking the density of oils and fatty acids at a steam heat:—He takes a small Sprengel tube, which is hung by the horizontal capillary portions in the neck of a 20-oz. flask containing water in a state of rapid ebullition. A watch-glass or porcelain crucible cover is placed over the neck of the flask so as to prevent cooling. The open mouths of the Sprengel tube project on opposite sides of the neck of the flask, while the mouth of the flask is sufficiently closed by the watch-glass or porcelain cover. When it is observed that the expansion of the oil has ceased, the mouths of the tube are touched with a piece of filter-paper to remove adhering oil, and the tube may then be taken out, wiped, cooled, and weighed. Fig. 3 will make the arrangement clear.

Fig. 3.



The following are some of the densities of fatty acids obtained by Archbutt in this way:*—

Source of fatty acids.	Density at 100° C.
Pure olive oil	·8444
,, ,,	·8429
Earth-nut oil	·8475
Pure rape oil	·8439
Colza oil	·8464
Cotton-seed oil	·8494
Niger-seed oil	·8562
Linseed oil	·8599
Train oil	·8597
Palm oil	·8389

3°. **Melting Point.**—Various methods have been suggested for determining the melting points of solid fats and fatty acids.

a. Dr. Bell's method.—The melted fat is suddenly cooled by floating the platinum capsule containing it in ice water. A small portion of the fat, which has a somewhat vitreous appearance, is then taken up on the loop of a platinum wire, and introduced, close to the bulb of a thermometer, into a beaker of water at 60° F. set in a porcelain dish also containing water. The heat of the water is then slowly raised, and the temperature read off immediately the fat assumes the liquid condition.

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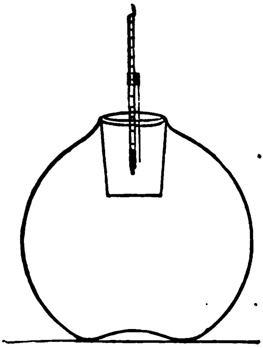
* "J. Soc. Chem. Ind." ii. 55.

b. Dr. Redwood's method.—A 20-oz. flask from which the neck has been removed is filled with water, and a small beaker is fitted into the mouth. The beaker is then half filled with clean mercury, and a small fragment of the solid fat or fatty acid is placed on the surface of the metal. The thermometer bulb must be wholly immersed in the mercury. The melting point is readily observed, and several samples may be tested simultaneously. Fig. 4 is an illustration of this arrangement.

Fig. 4.



c. Capillary tube method.—The apparatus employed is that last described with the addition of a capillary tube in close proximity to the bulb of the thermometer. The small beaker is in this case filled with water instead of mercury. Mr. Allen says very good results are obtainable by this method, provided the following points are rigidly attended to:—

(1) To allow the melted fat to solidify *slowly*, avoiding all artificial means of cooling.

(2) To allow at least an hour to elapse after solidification before taking the fusing point.

(3) To heat the water very slowly.

It may be useful here to note the following melting points of fatty acids obtained by this method by Mr. ARCHBUTT:*—

Source of fatty acid.	Melting Point. Fahr.	Melting Point. Cent.
Olive oil	75 to 76°	23·8 to 24·4°
Earth-nut oil	82·3	27·9
Rape oil	65	18·3
Colza oil	65	18·3
Cotton-seed oil	95·5	35·2
Niger-seed oil	76·5 to 80	24·7 to 26·6
Linseed oil	52·5	10·2
Train oil	87	30·5

d. An apparatus for the determination of melting points, by C. F. CROSS and E. J. BEVAN, was described in a paper read before the Chemical Society, January 19, 1882.† It consists of a small platform of thin ferrotype iron, or silver, having an opening for the reception of a thermometer bulb, and a small indentation or depression about 1·5 mm. deep and 2 mm. in diameter. A very small quantity of the substance is melted in the little depression, and, while still liquid, a thin platinum wire, bent like an L and fused at its upper extremity into a little glass float, is immersed in the liquid and held there till the substance solidifies; a thermometer is then inserted into the opening, and the whole apparatus plunged under mercury; the mercury is gently heated, and the thermometer carefully watched. (Water might be used instead of mercury.) As soon as the substance melts, the float rises, and the temperature is noted. Stirring is unnecessary; the whole of the substance is surrounded by mercury, and the attention can be concentrated on the thermometer.

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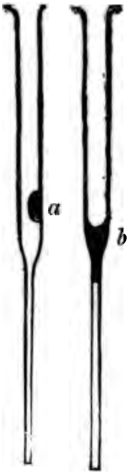
* "Journ. Soc. Chem. Ind." ii. 55.

† "Year Book of Pharmacy," 1882, 102.

e. BENSEMANN's method.*—A drop of the previously fused fat or mixture of dried fatty acids is placed in the wide portion of a drawn-out tube, as shown at *a* in Fig. 5, and is then allowed to completely solidify. The tube is placed perpendicularly, or nearly so, in a beaker of cold water containing a thermometer, and heated as gradually as possible over a very small flame until some of the fat begins to flow down the side of the tube. The temperature observed at this moment is called by the author the "initial point of fusion." The application of heat is continued until the fat drop has taken the appearance and position shown at *b*; and when the last trace of turbidity has disappeared, the temperature is again read off. This is the "concluding point of fusion." The author finds that this method gives very satisfactory and concordant results; the two points are very closely marked, and are about 3°–4° C. from one another. With pure fats the concluding point is less clearly marked than with fatty acids; in the examination of the former, therefore, the initial point only need be noticed. The table on p. 215 contains some of the results obtained.

FIG. 5.



4°. **Drying Properties of Oils.**—The drying quality of oils may be ascertained by placing a drop or two in a flat porcelain capsule, or spreading a drop or two upon a piece of glass, and setting aside overnight at common temperature, or, more quickly, at a gentle heat (about 100° F.). Or one of the methods given on pp. 292 and 302 may be adopted.

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* "Rep. Anal. Chem." 11, 165; "J. Soc. Chem. Ind." 1885, 535.

A similar quantity of a standard sample should be treated in the same way for comparison.

Table of Melting Points (BENSEMANN).

	Initial Point of Fusion of the Fat.	Percentage of Insoluble Fatty Acids	Initial Point of Fusion of Insoluble Fatty Acids.	Concluding Point of Fusion of Insoluble Fatty Acids.
Genuine butter-fat...	34-35° C.	87·77	42-43° C.	45-46° C.
Sesamé oil	Fluid	95·86	25-26	29-30
Cotton-seed oil	„	95·75	39-40	42-43
Olive oil	„	95·43	23-24	26-27
Refined rape oil ...	„	95·14	18-19	21-22
Earth-nut oil	„	95·86	31-32	34-35
Cacao fat from—				
Maracaibo beans ...	25-26°	94·59	48-49	51-52
Caraccas „ ...	27-28	95·31	48-49	51-52
Trinidad „ ...	26-27	95·65	49-50	51-52
Porto Plata „ ...	28-29	95·46	49-50	52-53
Machala Guayaquil beans	28-29	95·24	49-50	52-53

5°. **Viscosity.**—For the method of ascertaining the quality of an oil in this respect, see pp. 292 and 302.

6°. **Spectroscopic Examination.**—The fatty oils may be, according to DOUMER, divided into four classes with reference to their spectroscopic behaviour:—

1. Oils which show the absorption spectrum of chlorophyll, such as olive, hemp, and nut oils.

2. Oils which show no absorption spectrum (*i.e.*, which allow all the rays to pass unabsorbed), such as castor oil and oil of sweet and bitter almonds.

3. Oils which absorb all chemical rays of the spectrum. To this class belong rape, linseed, mustard, and other oils. Their spectrum is very characteristic: it only shows the warmer portion of the spectrum—red, orange, yellow, and one-half of the green. The balance of the spectrum is absorbed.

4. Oils whose absorption spectrum only comprises bands

of the chemical portion of the spectrum, instead of being complete—such as sesamé, poppy-seed, cotton-seed, and peanut oils.*

7°. **Cohesion Figures.**—Miss KATE CRANE † states that the cohesion figures of oils may be usefully employed as tests of the identity and purity of the oils. She says "a number of experiments on this subject have led her to the conclusion that a little patient practice will teach the eye of the observer in a short time to detect the characteristic differences of the figures. To make these perfect, it is necessary to observe the time in forming, for *at different periods* some varieties form figures very like; but with this precaution each is entirely characteristic.

"It is essential that the dish used, &c., be perfectly clean, so that when filled with water no dust or lint floats upon the surface, as this materially interferes with the perfect formation of the figure.

"A single drop is let fall from a burette or glass rod held steadily above the water, upon the centre of the surface. The experiments made with fixed oils are as follow:—*Poppy-seed oil* spreads instantly to a large figure, retaining an entire outline, and for a few seconds the surface is unbroken, except the bare intimation of a beaded edge.

"In a few moments little holes appear round the edge, and soon the whole surface is broken in like manner; these increase in size very slowly. In fifteen minutes the edge begins to open, forming indentations, which gradually work their way across the figure. As they increase in length these begin to curve, and in three-quarters of an hour have doubled themselves two or three times.

"*Cod-liver oil* spreads in a large film; a little way from the edge a row of small holes appears, and in a minute or two the surface is covered with them; these gradually enlarge, assuming irregular shapes, soon separated by branching lines.

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* "Analyst," 1885, 148.

† "American Journal of Phaimacy," iv. 406.

"*Cod-liver oil* with *lard oil* spreads very like the former, but in a few moments the edge opens, and the film separates partly across; in a moment one of the projecting points begins to curve itself towards the centre, bending more and more until it forms a coil; meanwhile a few holes have appeared, which spread irregularly, throwing out projecting points.

"*Castor oil* spreads instantly, the edge remaining entire; openings appear quickly in thirty seconds, and increase gradually, but unevenly, those nearer the edge being larger, and lengthening out irregularly as they spread. The figure lasts some time.

"*Castor* with a little *lard oil* makes a smaller figure, and not nearly so much broken; in five minutes the holes open into each other, and the figure breaks up from the edge.

"A mixture of *castor* and *poppy-seed oils* spreads to form a lacework border, but smooths out to an entire edge soon, and within a few seconds openings appear. The figure, in size and general appearance, is more like castor oil alone, but the holes spread less uniformly in a given time, a few being larger, but the greater portion much smaller. In fifteen minutes there is a general tendency to break up.

"*Castor* with a little *croton oil* throws out a spray, which in a few moments unites into a thin film. The spray, as it spreads, draws out the inner portion into radiate points, which open into a beautiful network, the centre cohering closely.

"*Croton oil* throws out, in spreading, a fine spray in advance of the more closely cohering portion, which follows quickly. The outer edge breaks up unevenly into little indentations, the border of the inside portion being quite broken, but gradually becomes nearly entire. The surface, too, has openings, which increase quite rapidly in size, the outer ones being much the larger. In the final breaking up, before the holes open one into another, the outlines are beautifully fringed."

For a table of some of the physical properties of the chief commercial fixed oils, see p. 219.

II. Chemical Tests.

A. *Qualitative.*

1°. Colour Tests.—*Sulphuric acid test.*—(*a*) HEIDENREICH was the first person who gave a useful and general application to the reactions which occur when oil of vitriol is mixed with the fatty oils. As soon as these substances are placed together, very intense chemical action commences, the temperature of the mixture rises, and the mass becomes coloured. These changes are sufficiently varied in the case of the different oils to furnish us with the means of identifying many of them, and of determining their purity. The method of M. HEIDENREICH is to lay a plate of white glass over a sheet of white paper; on the glass he places 10 or 15 drops of oil; and then adds to it a small drop of concentrated sulphuric acid. The appearances which follow differ with the character of the fatty oil examined, and whether the acid is allowed to act on the oil undisturbed or the two are stirred together with a glass rod. In many cases, as with tallow oil, a peculiar odour as well as a change of colour is developed, and a further means of detection supplied. M. HEIDENREICH has minutely described these reactions, which, for the most part, closely resemble those given in the table, pp. 229–30. It is necessary, however, in order to insure accuracy, to compare the effect of the reagent on the sample with those which it produces on pure oil of the same kind and character under precisely similar circumstances.

Name of Oil.	Specific Gravity at 15° C., Water = 1000.	Combustibility. Gms. consumed per hour in a Lamp with Wick.	Freezing Point in Degrees Centigrade.	Colour.	Taste.	Smell.	Limpidity, Time (in seconds) required to trickle a given distance.	Drying Power.
Plum-kernel ...	0·9127	68	− 9	Brownish yellow	Amygdalaceous	Very slight	93	Non-drying
Rape-seed	0·9128	30	− 4	Yellow	Nauseous	Nauseous	159	Non-drying
Colza	0·9136	40	− 9·25	Yellow	Nauseous	Nauseous	162	Non-drying
Cabbage-seed ..	0·9139	48·5	− 8	Yellow	Nauseous	Nauseous	148	Non-drying
White mustard	0·9142	29·8	− 16·25	Light yellow	Pleasant	Very slight	157	Non-drying
Ground-nut ...	0·9163	?	− 3	Pale greenish yellow	Like peas	Like peas	Not tested	Non-drying
Black mustard	0·9170	25	−17·5	Yellow	Pleasant	Very slight	141	Non-drying
Olive	0·9176	62	− 6*	Yellow	Sweet	Peculiar	195	Non-drying
Sweet almond.	0·9180	52·8	−21·5	Amber	Agreeable	None	150	Non-drying
Horseradish-seed...........	0·9187	43	−16·25	Yellowish brown	Pleasant	None	143	Non-drying
Grape-seed......	0·9202	37	−16·25	Gold yellow	Sweet	None	99	Dries slowly
Beech-nut	0·9225	50	−17·5	Amber	Very sweet	None	158	Non-drying
Pumpkin	0·9231	43	−15	Pale brown yellow	Sweet	None	185	Dries slowly
Land-cress......	0·9240	42	−15	Brownish yellow	Acrid	Disagreeable	103	Dries slowly
Hazel-nut	0·9242	53·4	−10	Amber	Sweet	None	166	Non-drying
Poppy............	0·9243	31	−18†	Pale yellow	Flat	None	123	Drying
Camelina	0·9252	34	−18	Yellowish	Peculiar	Peculiar	119	Drying
Walnut	0·9260	45	−27·5	Light yellow	Flat	None	88	Drying
Sunflower	0·9262	51·8	−16	Colourless	Sweet	None	114	Dries slowly
Hemp-seed ...	0·9276	46	−27·5	Dark greenish yellow	Disagreeable	Disagreeable	87	Drying
Cotton-seed ...	0·9316	?	− 2·5	Reddish brown	Strong	None	Not tested	Drying
Sesamé	0·9320	?	− 5	Bright yellow	Pleasant, slightly piquant	None	Not tested	Non-drying
Linseed	0·9347		−27	Dark greenish yellow	Strong	Disagreeable	88	Drying
Wood	0·9358	44	Not noted	Green	Unpleasant	None	73	Drying
Spindle	0·9360	61	− 20	Reddish brown	Acrid	Slight	143	Non-drying
Castor............	0·9611	47	−18	Colourless	Sickly	Very slight	1830	Dries slowly

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* Though these oils do not become quite solid till the point indicated is reached, yet they begin to become grainy at + 4° C.

† Once solidified, this oil does not liquefy until the temperature reaches 2° C.

(*b*) M. **Penot**, who has followed up the researches of M. **Heidenreich** with considerable success, recommends the employment of 20 drops of oil, instead of only 10 or 15; and the use of a small capsule of white porcelain, instead of a plate of glass. He also employs a saturated solution of bichromate of potash in sulphuric acid, which he uses in the same proportion as before; but in this case the oil and the reagent are always stirred together.

The observations of M. **Penot** have been repeated in many cases by Mr. **Cooley**, and the results, with additions, and re-arranged, are given in the table, pp. 229–30.

"By perusing this table," writes M. **Penot**, "it will be observed that the same oil does not, under all circumstances, yield precisely similar results with the same reagent. This depends on the place of growth, the age, and the manner of pressing. If, however, any oil be examined comparatively with a perfectly pure one, the proof of adulteration may be rendered, if not certain, at least probable, by noting the difference. Thus I obtained, by adding 1 part of either whale-train or linseed oil, or oleic acid, or 10 parts of rapeseed oil, the following results:—

Name of Oil.	Reagents.		
	Sulphuric Acid.		Solution of Bichromate of Potash.
	Not stirred.	*Stirred.*	*Stirred.*
Rape oil with whale-train oil	More red ground than with rape oil	Brownish-olive coloured	Small reddish lumps on a grey ground
Rape oil with linseed oil	No perceptible difference from the rape oil	Olive coloured	Small and more numerous red lumps on a very dark-green ground
Rape oil with olein or oleic acid	No perceptible difference from the rape oil	Greenish brown	Small brownish lumps on an olive-coloured ground.

"The adulteration being ascertained as far as is possible, the oil is then tested by endeavouring to discover the adulterating oil, either by reagents or by its odour when gently heated, as before described. This having been found out, small quantities of the suspected oil are added to a perfectly pure oil of the kind under examination. Every mixture is then tested by the reagents, until precisely similar results are obtained as those yielded by the oil under examination. Thus, the proportions of the two mixed oils will be discovered by approximation."

COLOUR REACTIONS OF CHATEAU.*

Method.—Into a small porcelain capsule, or on a porcelain slab, place 10 drops of the sample, and add from a dropping tube 5 drops of the reagent, and stir with a glass rod.

I. **Barium Polysulphide.**—This reagent is prepared by dissolving barium oxide in boiling distilled water, cooling, pouring off solution, boiling the decanted portion with excess of sulphur, and filtering.

1°. *Permanent gold colour.*

Vegetable Oils.

Almond
Colza
Cotton
Gingelly
Gold of pleasure
Linseed
Nut
Olive
Poppy
Rape

Animal Oils.

Neat's-foot (rarely)
Sperm

2°. *Transient gold colour.*

Vegetable Oils.

Beech-nut
Castor
Cocoa-nut
Ground-nut
Olive (inferior)
Poppy (Indian)

Animal Oils.

Cod-liver
Fish
Horse-bone
Neat's-foot
Whale
Seal

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* Extracted from SPON'S "Encyclopædia."

3°. *Greenish to greenish yellow.*

Vegetable Oil.

Hemp-seed

4°. *Evolution of sulphuretted hydrogen.*

Animal Oils.

Lard (yellowish at first—then bleached)	Tallow (yellowish—not afte wards bleached)

II. Zinc Chloride.—Made by saturating hydrochlori acid with pure zinc oxide, and evaporating till the liqui has the consistence of golden syrup.

1°. *White, or scarcely affected.*

Vegetable Oils.	*Animal Oils.*
Almond	Cod-liver (cold)
Cocoa-nut	Horse-bone
Gingelly (hot-pressed)	Lard
Nut	Neat's-foot
Poppy	Sperm
	Whale

2°. *Pale violet tinge.*

Animal Oil.

Cod-liver (cold)

3°. *Yellow.*

Vegetable Oils.

Castor	Linseed
Ground-nut	Rape

Animal Oil.

Fish.

4°. *Rose.*

Vegetable Oil.

Beech.

5°. *Brown.*

Vegetable Oil.	*Animal Oils.*
Cotton	Seal
	Whale

6°. *Bluish-green.*

Vegetable Oil.

Linseed (foreign)

7°. *Green.*

Vegetable Oils.

Colza

Gold of pleasure

Olive

Animal Oil.

Cod-liver

8°. *Milky, with green tinge.*

Vegetable Oil.

Almond

III. **Sulphuric Acid.**—Sp. gr. 1·843, and which has een shaken up with a little mercury occasionally during ome hours.

1°. *Brown shades.*

Vegetable Oils.

Beech
Cocoa-nut
Cotton
Ground-nut
Linseed (foreign)
Nut

Animal Oils.

Fish
Horse-bone
Lard
Neat's-foot (grey spots)
Seal
Sperm
Whale

2°. *Violet shades.*

Animal Oils.

Cod and other liver oils.

3°. *Yellow shades.*

Vegetable Oils.

Almond
Castor
Olive
Poppy

4°. *Greenish shades.*

Vegetable Oils.

Colza
Gold of pleasure
Hemp-seed
Linseed (English)
Rape

IV. **Stannic Chloride.**—The fuming perchloride of tin of commerce.

A. *Immediate Result.*

1. *Colourless.*

Vegetable Oil.

Sweet almond

2°. *Yellow shades.*

Vegetable Oils.	*Animal Oils.*
Poppy (French)	Neat's-foot
Castor	Lard
Olive	
Gingelly	
Cotton-seed	

3°. *Brown, or yellowish-brown, shades.*

Vegetable Oils.	*Animal Oils.*
Linseed (all qualities)	Neat's-foot
White poppy (India)	Lard
Nut	Horse-bone
Olive (infernal).	Whale
Pea-nut	Sperm
Gold of pleasure	Seal
Beech	Fish
Cocoa-nut	

4°. *Green, or bluish-green, shades.*

Vegetable Oils.

Linseed (English and others)
Hemp-seed
Rape
Colza

5°. *Violet-blue shades.*

Animal Oils.

Cod-liver
Ray

D. *Final Result.*—Colour of the thickened or solidified ma

1°. *Yellow shades.*

Vegetable Oils.

Poppy (French)
„ (India)
Castor
Olive (refined)
Gingelly
Almond (sweet)
Gold of pleasure

Animal Oil.

Sheep-foot.

2°. *Orange-yellow shades.*

Vegetable Oil.

Colza

Animal Oils.

Neat's-foot
Horse-bone
Sperm

3°. *Brown, or reddish-brown, shades.*

Vegetable Oils.

Linseed
Pea-nut
Beech
Cotton-seed

Animal Oil.

Whale

4°. *Greenish shades.*

Vegetable Oils.

Hemp-seed
Olive (inferior)
Rape-seed

V. Phosphoric Acid.—Syrupy phosphoric acid—*i.e.*, ordinary phosphoric acid evaporated to a sp. gr. of 1·72.

A. Stir and observe.—*Cold.*

1°. *Little change, if any.*

Vegetable Oils.

Poppy
Nut
Castor
Almond
Rape (?)
Gold of pleasure (?)
Cocoa-nut

Animal Oils.

Neat's-foot
Lard

2°. *Yellow shades.*

Vegetable Oils.

Linseed (foreign)
Ground-nut
Cotton

Animal Oil.

Sperm

3°. *Orange-yellow shades.*

Vegetable Oil.

Gingelly.

Animal Oils.

Horse-bone
Whale

4°. *Brownish, or reddish-yellow, shades.*

Animal Oils.

Seal
Fish
Cod-liver

5°. *Greenish to bluish shades.*

Vegetable Oils.

Linseed (English)
Hemp-seed
Olive
Colza
Rape
Gold of pleasure

B. Heat, and observe :—

1°. *Colourless.*

Vegetable Oils.

Poppy
Olive (sometimes)
Cocoa nut (sometimes faint yellow)

Animal Oil.

Lard (sometimes very faint yellow)

2°. *Yellowish shades.*

Vegetable Oil.

Ground-nut

Animal Oil.

Horse-bone

3°. *Brownish-yellow shades.*

Vegetable Oils.

Linseed
Poppy
Hemp-seed
Nut
Castor
Olive
Almond
Rape
Colza
Beech
Cotton
Gingelly
Gold of pleasure

Animal Oils.

Neat's-foot
Sperm

4°. *Deep-brown shades.*

Animal Oils.

Seal
Fish
Whale
Cod-liver

5°. *Froth—greenish shades.*

Vegetable Oils.

Gingelly
Hemp-seed

Animal Oils.

Whale
Cod-liver

6°. *Froth—grey.*

Vegetable Oils.

Olive
Ground-nut
Gold of pleasure
Cotton

Animal Oil.

Sperm.

7°. *Froth—blackish.*

Vegetable Oils.

Linseed
Castor
Rape
Colza
Beech

Animal Oils.

Neat's-foot
Seal
Fish

VI. Mercuric Nitrate.—Dissolve mercury to saturation in cold nitric acid, and then boil for ten minutes with as much more nitric acid. First observe the effect given by the salt alone, and then add 2 or 3 drops of sulphuric acid, and observe the colour of the liquid which covers the precipitate.

A. Colours given by the salt alone.

1°. *No coloration.*

Vegetable Oils.

Nut
Beech

Animal Oil.

Sperm

2°. *White, or greyish-white, emulsion.*

Vegetable Oils.

Poppy (French)
White poppy
Castor
Sweet almond
Gingelly

Animal Oils.

Neat's-foot (Paris)
Lard

3°. *Yellowish shades.*

Vegetable Oils.

Linseed
Olive (refuse)
Rape
Pea-nut
Gold of pleasure
Cotton

Animal Oils.

Whale
Fish
Cod
Ray

4°. *Orange-yellow.*

Vegetable Oil.

Gingelly.

Animal Oil.

Horse-bone

5°. *Reddish-yellow shades.*

Animal Oils.

Neat's-foot
Seal

6°. *Flesh-coloured.*

Vegetable Oil.

Cocoa-nut

7°. *Greenish shades.*

Vegetable Oils.

Linseed (English)
Hemp-seed
Olive
Colza
Rape
Gold of pleasure

B. Colour of the liquid above precipitate, by sulphuric acid added after mercury nitrate.

1°. *Grey shades.*

Vegetable Oils.

Hemp-seed
Colza
Rape

2°. *Yellow shades.*

Vegetable Oils.

Linseed
Castor
Gingelly (green veins)

3°. *Reddish-yellow shades.*

Vegetable Oils.

Linseed (Bayonne)
White poppy
Olive (ordinary)

Animal Oils.

Neat's-foot
Horse-bone

4°. *Brown shades.*

Vegetable Oils.

Linseed
Poppy (French)
Nut
Castor
Hemp-seed
Cocoa-nut
Olive
Sweet almond
Colza
Pea-nut
Gold of pleasure
Beech
Cotton

Animal Oils.

Neat's-foot
Lard
Horse-bone
Tallow
Whale
Sperm
Seal
Fish
Cod-liver
Ray-liver

5°. *Sudden effervescence.* Disengagement of vapours of nitrogen compounds.

Vegetable Oils.

Linseed
Nut
Castor

Animal Oils.

Tallow
Seal

TABLE ***giving the reactions of various*** **OILS** ***with*** **SULPHURIC ACID** ***and with a saturated solution of*** **BICHROMATE OF POTASH** ***in sulphuric acid.*** **Re-arranged from M. PENOT's table, with additions, by Mr. COOLEY.**

⁂ ***The result indicated is obtained in each case by the action of*** **one drop** ***of the*** **REAGENT** ***on*** **twenty drops of OIL.**

Name of Oil.	Reagents.		
	Sulphuric Acid.		Saturated Solution of Bichromate of Potash in Sulphuric Acid.
	Not Stirred.	*Stirred.*	*Stirred.*
Almond oil	Greenfinch yellow, with orange spots	Dirty green	Yellowish, small lumps
Castor oil	Yellow, with slight spots	Little reaction	Slightly green
Cod-liver oil (*fine sample of pale oil*)	Deep purple in the centre, rapidly turning brown, whilst violet or purple clouds or streaks spread out towards the circumference, the colour of which remains unaltered for some minutes after the central portion has turned nearly black	Deep purple, passing into purple brown, reddish brown, and gradually deepening to an intense brown, approaching black	Reddish-brown clots changing to a clear bright green
Hemp-seed oil	Small brown lumps or clots on a yellow ground	Greenish brown	Small yellow lumps or clots on a green ground
Linseed oil (*from the Upper Rhine*)	Dark reddish brown	Brown small lumps on a grey ground	Brown small lumps on an almost colourless ground
Ditto (*from Paris*)	Reddish brown, less dark coloured	Brown clots on a green ground	Brown small lumps on a green ground
Ditto (*English*)......	Chestnut brown	Brown clots on a greenish-grey ground	Brown lumps on a greenish-grey ground
Liver-train oil	Dark red	Dark red	Dark red
Madia-sativa oil ...	Slightly reddish brown underneath a thin greyish film	Olive green	Light brown small lumps on an olive-coloured ground
Black-mustard oil..	Bluish green	Olive green	Olive brown

PENOT'S and COOLEY'S Table—*continued.*

Name of Oil.	Reagents.		
	Sulphuric Acid.		**Saturated Solution of Bichromate of Potash in Sulphuric Acid.**
	Not Stirred.	*Stirred.*	*Stirred.*
Neat's-foot oil	Yellow, slight spots	Dirty brown	Brown spots on a brownish ground
Nut oil (*recent*) ...	Yellowish brown	Clotted, dark brown	Small brown lumps or clots
Ditto (*one year old*)	Yellow	Dirty brown, less dark coloured	Small brown lumps
Ditto (*still older*) ...	Orange yellow	Dirty brown	Small brownish lumps
Olein, oleic acid, lard, or tallow oil	Reddish spots, with reddish circles	Reddish brown	Bright chestnut colour
Olive oil..............	Yellow	Dirty brown	Olive brown
Ditto (*another sample*)	Orange yellow	Brownish grey	Brown
Ditto (*from fermented olives*)	Orange yellow	Brownish grey	Brown
Poppy oil (*recent cold drawn*)	Yellow spots	Olive brown	Small yellow lumps on a white ground
Ditto (*recent*, expressed with slight heat)	Greenish-yellow spots	Olive brown, turning more on the green	Small yellow lumps on a greenish-grey ground
Ditto (*one year old, expressed with heat*)	Greenish spots	Olive green	Small yellow lumps on a green ground
Rape or colza oil (*trade*)	Yellowish-brown streaks surrounded by a bluish-green ring	Brownish, turning on the olive green	Yellow small lumps on a green ground
Ditto (*recent*)	Green	Bluish green	Yellow small lumps on a green ground
Ditto (*one year old*)	Green	Bluish green	Yellow lumps on a brighter green ground
Ditto (*one year old, rough hot-pressed*)	Green	Olive green	Small yellow lumps, more numerous on an olive-green ground
Whale train oil ...	Small reddish lumps on a brownish ground	Resembles wine lees	Small, bright, chestnut-coloured lumps on a brown ground

Glössner's Table for the Detection of Fat Oils.[*]

I. 5 vols. oil + 1 vol. caustic potash (sp. gr. 1·34) are well shaken together.

The resulting mass is—

At Ordinary Temperatures.

1°. *Snow-white.*
- Almond
- Good rape (bleached)
- Olive

2°. *Yellowish.*
- Poppy
- Olive
- Rape
- Sesamé

3°. *Greenish.*
- Linseed
- Hemp
- Oils containing copper, and artificially coloured oils

4°. *Rose.*
- Rape (refined)

After Boiling.

5°. *Brown and solid.*
- Hemp

6°. *Yellowish-brown fluid.*
- Linseed

7° *Red.*
- Train

II. Equal vols. of oil and fuming nitric acid are carefully poured into a test-glass. At the point of contact a ring is formed, and this is—

At Ordinary Temperatures.

1°. *Small and bright green.* The oil itself is flocky and non-transparent.
- Almond

2°. *Dark green, rose-coloured above.*
- Poppy

3°. *Broad and bright-bluish green.*
- Olive

4°. *Brown-red.*
- Cod-liver

After Boiling.

5°. *Green—red above.*
- Linseed

6°. *Brownish-red, greenish below.*
- Rape

7°. *The whole coloured red,* after a time.
- Linseed

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[*] "Chem. Centr." 1873, 57; Watts' "Dict. of Chemistry," vol. viii. part ii. 1428.

III. To the oil is added pure concentrated sulphuric acid in a test-glass. The point of contact between the two is coloured.

A. 10 drops of oil + 2 drops of the acid.

1°. *Fine green*, brown streaks.
Rape
2°. *Yellow;* on shaking, brownish-olive green.
Poppy
3°. *Red*, soon passing into serpentine black streaks.
Train

B. Equal vols. of oil and acid.

(a) *Without carbon bisulphide.*

1°. *Fine full dark-green* after shaking.
Rape
2°. *Green.*
Linseed
Hemp
3°. *Red.*
Train

(b) *With carbon bisulphide, 20 vols.*

4°. *Violet*, quickly turning brown.
Train

IV. By the elaïdin test the oil becomes—

1°. *Solid, curdy, white.*
Olive
Almond
Rape (bleached)
2°. *Solid, curdy, yellow.*
Rape
3°. *Solid and red.*
Sesamé
4°. *Wax-like white.*
Castor
5°. *Streaks and drops of oil in the elaïdin.*
A mixture containing drying oils
6°. *Unchanged.*
Linseed
Poppy
Nut

Note.—Ethereal oils, added to improve the smell of olive oil, swim on top of the elaïdin.

V. By boiling with lead oxide and water, a plaster is formed. The consistency of this is—

1°. *Solid.*
  - Olive

2°. *Greasy.*
  - Rape
  - Almond
  - Sesamé

3°. *Greasy,* but drying after a time.
  - Drying oils

VI. Solubility of 1 part of oil in alcohol.

1 : 1	Castor
1 : 25	Poppy
1 : 30	Hemp
1 : 40	Linseed
1 : 60	Almond

Colour after passing Chlorine Gas.—The presence of fish oil in vegetable oils may be detected by passing a stream of chlorine through them. The pure vegetable oils are not materially altered, but a mixture of the two turns dark-brown or black.

2°. **Increase of Temperature with Sulphuric Acid.**—M. Maumené proposed the increase of temperature arising from the admixture of monohydrated sulphuric acid, (sp. gr. 1·845) with the fatty oils as a test of their purity. According to MM. Faisst and Knauss, who have re-examined the subject, the following are the results when 15 gms. of oil are mixed with 5 gms. of the acid:—

	Rise of Temperature.
Almond oil	72·5° F.
Olive oil	68·0
Poppy oil	127·0
Rape or colza oil	100·0
Linseed oil (with Nordhausen or fuming acid only)	133·0

This method is less liable to error when larger quantities of the substances are thrown together.

The following are the results obtained by Maumené, 50 gms. of the oil being taken, its temperature noted, and then 10 c.c. of the acid added gradually, stirring with the thermometer until the temperature ceased to rise :—

	Rise of Temperature.		Rise of Temperature.
Olive oil	108° F.	Gingelly oil	154 F.
Castor oil	116	Poppy oil	187·5
Neat's-foot oil	122·7	Hemp oil	208
Bitter almond oil	125	Nut oil	214
Sweet almond oil	126 5	Train (ray-liver) oil	215·5
Rape oil	134	,, (cod) oil	215·5
Beech-nut oil	149	Linseed oil	217
Ground-nut oil	152		

In the application of this test, constancy of results is only to be looked for when the process is in each case performed strictly in the same way.

3°. **Elaidin Test.**—This is very useful in discriminating between "drying" and "non-drying" oils. The following are methods of applying the test :—

(*a*) (Ph. E.) Mix the oil with $\frac{1}{12}$th part of its volume of a solution of 4 oz. of mercury in 8 oz. 6 dr. of nitric acid (sp. gr. 1·5).

(*b*) M. Pontet recommends the mercurial solution to be made by dissolving 6 parts of mercury in 7½ parts of nitric acid (sp. gr. 1·35) without heat. Of this solution he adds 1 part to every 48 parts of the oil, and well shakes the mixture every thirty minutes till it begins to solidify. A temperature of about 90° F. (32·2° C.) is the best to cause the oil and coagulum to separate perfectly from each other.

(*c*) Another method of procedure is to add to the oil in a tube a small globule of mercury or some copper turnings and then pour in nitric acid.

(*d*) Massie[*] used 5 gms. of nitric acid, sp. gr. 1·4, and 1 gm. of mercury to 10 gms. of oil.

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[*] "Journ. de Pharm. et de Chim." [4] xii. 13, 1869; Dragendorff's "Plant Analysis" (translation by Greenish).

When the coagulum obtained from pure olive oil is pressed and treated with alcohol, it furnishes a white crystalline fatty substance termed *elaïdin.* This body resembles a neutral fat in properties, melts at 90° F. (32·2° C.), dissolves with difficulty in boiling alcohol, easily in ether, and is resolved by saponification into glycerine and *elaïdic acid.* Elaïdic acid appears to have the same composition as oleic acid.

By Massie's method the following oils solidified in the times mentioned :—

Almond .	1¼ hour	Sesamé .	2½ hours	Rape . .	3 hours
Hazel-nut .	1 „	Apricot .	1¾ „	Colza . .	3½ „
Olive . .	1 „	Beech .	6 „	Cotton .	1¾ „
Ground-nut	1¾ „				

4°. **Spontaneous Combustion** ensues when a handful of cotton waste is embued with oil and placed in an air bath at 130° to 200° F. Boiled linseed oil required an hour and a quarter; raw linseed oil, four hours; lard oil, four hours; refined rape, about nine hours.

Gellatly found that an admixture of 20 per cent. of mineral oil retarded combustion, and 50 per cent. prevented it completely.

5°. **Solubility in Acetic Acid.***—Equal parts of oil and acid are mixed and submitted to various temperatures :—

1°. *Completely soluble at ordinary temperatures* (15°–20° C.).

Olive-kernel	Castor

2°. *Completely, or almost completely, soluble at temperatures between* 23° C. *and the boiling point of acetic acid.*

Palm . .	at 23°	Green olive	at 85°	Yellow olive	at 111°
Bay . .	„ 27	Pumpkin-seed	„ 108	Earth-nut	„ 112
Mace . .	„ 27	Almond .	„ 110	Tallow .	„ 95
Cocoa-nut .	„ 40	Cotton-seed	„ 110	Cod-liver .	„ 101
Palm-kennel	„ 48				

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* Valenta, "Dingl. Polyt. Jour." 252, 296; "J. Soc. Chem. Ind." 1884, 524.

3°. *Incompletely soluble at the boiling point of acetic acid.*

Rape	Hedge mustard

Note.—The figures give the temperatures at which the cooling solution begins to be turbid.

Chemical Tests.

B. *Quantitative.*

1°. Determination of Free Acid, and Action on Copper.—M. Burstyn,[*] believing that the value of a fatty oil as a lubricant depends on the amount of acid it contains, proposed the following method for volumetrically determining the acidity :—A tall cylindrical vessel, provided with a ground-glass stopper, and having two marks on it to indicate respectively 100 c.c. and 200 c.c., is filled to the first mark with the oil to be tested, and to the second mark with 88 to 90 per cent. alcohol. The cylinder is then closed and well shaken. Equal quantities other than 100 c.c. can be employed without any other change in the process. After standing two or three hours, the oil settles, and the clear alcohol, which contains in solution the free acids and a little of the oil, rises to the top perfectly clear; 25 c.c. of the clear alcohol is taken from the top by means of a pipette. A few drops of alcoholic extract of turmeric are added, and the acid determined by means of a standard solution of potash as in acetometry. The change from yellow to brownish-red takes place with great sharpness when neutralization is reached.

The number of cubic centimètres of potash employed, multiplied by four, gives the quantity of normal solution requisite to neutralize the free acid in 100 c.c. of oil. As it is not an individual acid, but a variable mixture of acids, it is not possible to calculate the percentage of acids present. These numbers, however, may be taken as degrees of acidity. For instance, an oil of 3° of acidity is one which contains enough free acid to neutralize 3 c.c. of normal alkali.

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[*] Ure's "Dictionary of Arts," &c.

If we assume that oleic acid predominates, which in most cases is the fact, 1° of acidity corresponds to 0·28 per cent. by weight of oleic acid. The olive oil of commerce has an acidity ranging from 0·4° to 12°. The first passes as very fine, and is called free from acid or salad oil, while the latter is known by smell and taste as very rancid. Oil that has 4° to 6° of acidity has been found to answer very well as a lubricator.

The following is the method of procedure adopted by L. ARCHBUTT:*—

1. Two tall, narrow-mouthed, colourless glass bottles, of about 400 c.c. capacity, are taken. One bottle is divided, by file marks on the side, into four parts of about 100 c.c. each.

Ordinary normal soda solution (40 gms. NaHO per litre) is used for the titration.

2. The divided bottle is filled with re-distilled methylated spirit, a few drops of phenol-phthaleïn solution added, and normal soda run in, drop by drop, until the liquid is coloured a faint pink. This quantity of neutralized alcohol serves for four titrations.

3. The other bottle is counterpoised on a large balance, and 50 gms. of the oil are weighed into it. 100 c.c. of the neutral spirit are added, and a few drops more phenol-phthaleïn, and then normal soda is run in until the mixture, after being violently shaken, is permanently coloured just pink. One drop of soda (= ·03 per cent. of oleic acid) in excess will produce this result. The number of cubic

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* "Analyst," August 1884, p. 170.

centimètres employed × ·562 gives the percentage of free fatty acid, stated as oleic acid. The determination can thus be accurately made in a few minutes with very little trouble. The bottle containing the oil and alcohol, when emptied and allowed to drain for a few seconds, is ready for the next sample.

In the case of palm oil (which is often coloured red) and other solid fats, the process requires to be slightly modified. If the sample be very red, it will not be possible to work on a much larger quantity than 5 gms., and, as a rule, it will be found most convenient to take from 5 to 10 gms. of any solid fat. The result will not be quite so accurate as by using a larger quantity, but it will be sufficiently so for most purposes. A portion of the fat is melted in a beaker, and of this 10 gms. are weighed into a short, wide-necked flask of about 150 c.c. capacity. 20 c.c. of neutralized spirit are added and some phenol-phthaleïn, and then normal soda, as before, until the pink colour is permanent after vigorous shaking. During the titration the fat is kept in a melted condition by warming the mixture occasionally. Even when palm oil is very red, with a little care it is quite easy to detect the change. Experiment upon neutral palm oil has shown that no saponification of the fat takes place. The number of cubic centimètres of soda required × ·255 gives the corresponding weight of free palmitic acid in the quantity of oil taken.

Some oils are liable to contain a small quantity of free *mineral* acid which has not been washed out after refining. It is obvious that the process described above makes no distinction between mineral and fatty acid, but simply estimates the total acidity. Free mineral acid may, however, be readily detected and estimated by shaking the oil with water and methyl orange, instead of spirit and phenol-phthaleïn, the former indicator being unaffected by fatty acids. In this case it is better to separate the oil from the water before titrating. In the case of dark-coloured mineral oils this precaution is essential.

The following factors will be useful:—

1 c.c. of normal soda is equivalent to
·281 gm. oleic acid
·283 „ stearic acid
·255 „ palmitic acid

The results of W. H. WATSON's experiments upon the corrosive action of various oils on copper and iron are as follow:—

	Copper dissolved after 10 days.	Iron dissolved after 24 days.
Linseed oil	0·3000 gr.	0·0050 gr.
Olive oil	0·2200	0·0062
Neat's-foot oil	0·1100	0·0875
Almond oil	0·1030	0·0040
Seal oil	0·0485	0·0050
Colza oil	0·0170	0·0800
Sperm oil	0·0030	0·0460
Paraffin oil	0·0015	0·0045
Lard oil	—	0·0250
Castor oil	—	0·0048
Special lubricating oil	—	0·0018

Of the oils used, paraffin and castor oils had the least action on the metals, and sperm and seal oils are next in order. The appearances of the paraffin and the copper were not changed after seventy-seven days' exposure. Different oils produce, with copper, compounds varying in colour, and hence a comparison of their action from mere observance of resulting colour is impossible. There is no relation between the action of an oil on copper and on iron.*

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* "J. Chem. Soc." 1881, 772.

What relation there exists between the degree of acidity and any injurious effect upon metals is shown by the following experiments:—Four shallow vessels of sheet brass, having a surface of 40 square centimètres each at the bottom, were filled to the depth of 2 millimètres with oils of different acidity, and exposed to the air at the ordinary temperature. The vessels were soon more or less covered with green fatty salts, and the oil too acquired a green colour. Oil and vessel No. 1 were the only ones in which no change could be perceived. At the end of three days the vessels were cleaned with ether, and weighed. The following table shows the amount of action:—

Vessel No. 1,	filled with oil of	0·8°	lost	0·03 gr.
„ No. 2,	„	4·6	„	0·22
„ No. 3,	„	7·8	„	0·36
„ No. 4,	„	8·8	„	0·40

The quantity of metal destroyed, in equal times and under equal conditions, increases with the acidity of the oil.

2°. **Saponification Test.**—This test is applicable both to fats, or oils, in which there are no glycerides of soluble acids, and also to fats in which glycerides of soluble acids are present.

Dr. Bell* thus describes the process:—"A solution of soda of indefinite or of known strength may be used according to whether the insoluble acids or the acids of both kinds are sought to be known. The former method was first applied by Hehner and Angell, in the analysis of butter; but an improvement in the process, which enabled both descriptions of acids to be ascertained, was suggested by Dupré. Two solutions are prepared—one a normal alcoholic solution of soda, and the other sulphuric acid, slightly stronger than the soda solution. An assay flask of stout glass, provided with a tightly fitting cork, or india-rubber stopper, is selected. A quantity of dry melted butter-fat" (or oil), "from 4 to 5 gms. is placed in the flask and 25 c.c. of the normal alkali are added, the cork tied down with a piece of leather or canvas, and the flask placed over a water-bath for one hour, the contents being gently shaken from time to time with a circular motion. The flask is then removed, allowed to stand till nearly cold, and the solution washed with hot water into a larger flask of about 200 c.c. capacity, and having a short wide neck. The flask is placed on a water-bath for an hour, or until most of the alcohol has evaporated, and the soap is then, while quite hot, decomposed by the addition of 25 c.c. of the sulphuric acid solution. The insoluble fatty acids rise to the surface; but it is generally necessary to shake the contents occasionally, to bring the fats into the form of an oil before proceeding to separate them from the other fatty acids." If there are soluble acids to estimate, as in butter, "at the same time 25 c.c. of the sulphuric acid solution are added to 25 c.c. of the soda solution, and the excess of acid ascertained by neutralizing the mixture with a *deci-normal* solution of soda, and a note made of the number of cubic centimètres required for this purpose. A Swedish filter-paper of the *best* quality is dried and carefully tared, placed in a glass funnel, and thoroughly wetted with boiling water. The contents of the flask are transferred to the filter, and the flask repeatedly washed with hot water, until all traces of fat are removed to the filter. The filter-paper and fatty acids are also well washed, until the filtrate ceases to be sensibly acid to test-paper, which is usually when from 600 to 700 c.c. of filtrate have been obtained. The filter and insoluble fatty acids, when sufficiently cool, are removed to a weighed platinum dish, dried in a water-oven at 212° F. (100° C.), and weighed. This weight, less that of the filter and platinum capsule, gives the amount of insoluble fatty acids in the quantity of fat taken. If the fat appears to have been imperfectly removed from the flask, it is desirable to wash out the flask with a little ether, and evaporate in a separate vessel. It is seldom, however, that more than mere traces of fat are found by this treatment."

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* "Analysis and Adulteration of Foods," ii. 56.

"To obtain the soluble fatty acids, the filtered solution is titrated with deci-normal soda solution. The number of cubic centimètres required, less the number of cubic centimètres by which the sulphuric acid solution exceeds the soda as noted above, represents the free acids derived from the butter-fat. It has been found convenient to calculate these as butyric acid ($C_4H_8O_2$). In an experiment in which 5 gms. of butter-fat were used and the excess acidity of the sulphuric acid was 4·5 c.c., and the total acidity 37·5 c.c. of deci-normal soda, then, as ·0088 gm. is the butyric acid equivalent of 1 c.c. of deci-normal soda, $(37{\cdot}5 - 4{\cdot}5) \times {\cdot}0088 \times 100 \div 5 = 5{\cdot}80$ per cent. as butyric acid."

3°. **Determination of the Oleic Acid in the Insoluble Fatty Acids.**—1. If it is desired to determine the proportion of oleic acid, the insoluble acids must be converted into a lead soap by heating with finely divided litharge. The oleate of lead is then dissolved out of this soap by repeatedly digesting it with warm ether, and filtering. The oleate of lead in the ethereal filtrate is decomposed with dilute hydrochloric acid. The solution containing the liberated oleic acid is decanted or drawn off from the lead chloride, evaporated, and the residue, consisting of the oleic acid, weighed in a capsule or beaker.

2. The following is Dr. MUTER's method of estimating oleic acid in fats:*—The first important matter is to insure the formation of a *perfectly neutral* plumbic oleate

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* "Analyst," 1878, 73.

($Pb_2C_{18}H_{33}O_2$), as the slightest quantity of basic oleate will render the analysis inaccurate, owing to its much less degree of solubility in ether. To attempt this by the ordinary method of saponification with plumbic oxide Dr. Muter considers quite hopeless, but it may be readily attained in the following manner:—About 1·5 gm. of the fat is saponified by alcoholic potash and then well diluted with boiling water. The solution is carefully treated with acetic acid till feebly acid, and then worked back with dilute potash till just neutral. This can be done without the use of test-paper by adding the acid to the soap solution at the boiling point until a decided *permanent* turbidity is produced, and then dropping in the potash with *constant stirring*, until the liquid *just clears again*. The clear solution is then precipitated by plumbic acetate in slight excess, and stirred until the precipitated soap settles thoroughly. The supernatant liquor is poured off, and the soap washed once by boiling with a large volume of water, and decanting. By this process the perfectly neutral lead salts are obtained, containing—

Plumbic oleate	$Pb_2C_{18}H_{33}O_2$
„ palmitate . . .	$Pb_2C_{16}H_{31}O_2$
„ stearate . . .	$Pb_2C_{18}H_{35}O_2$

the first being readily soluble in ether, and the two latter quite insoluble. The soap is scraped from the basin with a platinum spatula, and transferred to a flask of 100 c.c. capacity. The basin is rinsed into the flask with absolute ether, and then the glass is filled up with the same solvent, corked, shaken at intervals for some hours, and finally set to subside. The whole is then filtered through white filter-paper, and the precipitate washed with ether till the washings cease to blacken with ammonium sulphide. The filtrate and washings (which should not exceed 200 c.c.) contain the plumbic oleate, whilst the palmitate and stearate remain in the filter.

Having thus got a solution of the pure neutral lead soap in ether, it is transferred to a long graduated tube holding 250 c.c., graduated from the bottom upwards, and furnished with a well-ground stopper, and a stop-cock which is placed at 50 c.c. from the bottom. About 20 c.c. of a mixture of 1 part of hydrochloric acid and 2 parts of water is then added, the stopper is inserted, the tube well shaken, and set to allow subsidence, when a clear solution of oleic acid remains, the plumbic chloride sinking to the bottom. When sufficiently settled, a known portion of the ethereal solution is run off through the stop-cock into a tared platinum dish, evaporated, and dried at 212° F., and the oleic acid is weighed and calculated on the whole bulk. To make sure, it is well to run off two different quantities, and weigh the residues, so checking one with the other.

If it is desired to estimate the stearic and palmitic acids together, the residue should be filtered, and the soap remaining in the filter detached and heated for some time (with constant stirring) with dilute hydrochloric acid, which will liberate the acids so that they may be collected and weighed in the usual manner. The filter-paper is also to be burned, and the ash treated with a drop or two of sulphuric acid, and any lead remaining in the filter weighed as sulphate, 303 parts of which are equal to 568 parts of stearic acid. Two samples of butter experimented on in this way gave the following results:—

	Sample yielding 88·5 per cent. Insoluble Acids.	Sample yielding 87·1 per cent. Insoluble Acids.
Oleic acid	40·4	34·8
Stearic and palmitic acids ...	47·5	52·1
Total	87·9	86·9

Determination of the Stearic and Palmitic Acids.*—If it is requisite to find the approximate proportion of each of these acids, the process is as follows:—The mass of mixed acids, obtained as above, is melted, and a little is sucked up into a pair of glass tubes, drawn out at one end into a long thin point, until the drawn-out parts are completely filled. They are then both allowed to cool, and afterwards suspended in a beaker of water, with a thermometer between them. Heat is applied, and the temperature noted at the moment when the tube contents become transparent. They are again allowed to cool gradually, and the temperature read off at the instant of re-solidification. By reference to the following table an approximate result is obtained:—

Melting and Solidifying Points of Mixtures of Stearic and Palmitic Acids (HEINTZ).

Proportion by Weight of		Mixture.			
		Melts at		Solidifies at	
Stearic Acid.	Palmitic Acid.	Cent.	Fahr.	Cent.	Fahr.
90	10	67·2	153°	62·5°	144·5°
80	20	65·3	149·5	60·3	140·5
70	30	62·9	145·25	59·3	138·75
60	40	60·3	140·5	56·5	133·75
50	50	56·0	133·75	55·0	131
40	60	56·3	133·25	54·5	130
35	65	55·6	130·25	54·3	129·75
30	70	55·1	131	54·0	129·25
20	80	57·5	135·5	53·8	128·8
10	90	60·1	140·9	54·5	130·1

To get a fair approximation, both the melting and re-solidifying points must be taken.

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* MUTER, SPON'S "Encyclopædia."

A more accurate, but at the same time more tedious, method of estimating stearic and palmitic acids is the fractional precipitation process described by HEINTZ. The cake of the mixed acids already mentioned is pressed between folds of filter- or blotting-paper, and then dissolved in ether, and the solid portions crystallizing out are, if necessary, redissolved in ether till a fat is obtained melting at about 60° C. (140° F.). This is dissolved in such a quantity of hot alcohol that nothing will separate out on cooling, even to 0° C. To this hot alcoholic solution a boiling alcoholic solution of magnesic acetate is added (1 part of the salt to 4 parts of the mixed acids). The magnesium salt which separates on cooling is pressed, and boiled for some time with excess of dilute hydrochloric acid to decompose it. The stearic acid obtained is not pure, but contains some palmitic acid, from which it must be separated by repeated crystallization from alcohol, till its melting point is between 69° and 70° C.

4°. **Koettstorfer's Saponification or Saturation Equivalents.***—This process estimates volumetrically the number of equivalents of acids contained in butter and other fats from the amount of potash necessary for complete saponification, and fats may be thus distinguished from each other by calculating the differences in potash used. The method is simple and rapid in execution, since it may be performed in half an hour, provided all necessary standard solutions are ready. The author of the process uses half normal hydrochloric acid, and a solution of potash, in highly rectified spirit, of about the same strength. A dilute alcoholic solution of phenol-phthaleïn is used as indicator, the same quantity of the indicator being always used in each experiment.

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* "Analyst," 1879, 106.

The examination is conducted as follows:—1 to 2 gms. of the fat, purified by melting and filtration, are weighed in a tall beaker of about 70 c.c. capacity; 25 c.c. standard alcoholic potash are added, and the whole heated in a water-bath. When the alcohol is nearly boiling, the mixture is stirred with a glass rod till all the fat is dissolved, which does not take more than a minute. The glass rod is then taken out, and washed with a little alcohol. The beaker is covered with a watch-glass, and heated further for fifteen minutes, in such a manner that the alcohol does not boil too violently. The covering glass is then washed with spirit, and the alcoholic solution is stirred with the glass rod for one minute longer, so as to saponify any trace of fat that might still adhere to it. The solution is now taken from the water-bath, 1 c.c. of the alcoholic phenol-phthaleïn is added, and it is titrated back with half-normal hydrochloric acid. The point of neutrality is very sharply indicated, the liquid becoming pure yellow when changing to the acid reaction.

From the difference between the amounts of hydrochloric acid required by 25 c.c. standard alkali, and the amount used in the above titration, the amount of KHO combined with the acids of the fat is calculated.

The standard potash solution is to be titrated afresh on each occasion, and, before testing with the standard acid, 25 c.c. of it should be heated for fifteen minutes in a water-bath, as in the saponification of the sample. Standard sulphuric acid cannot well be substituted for hydrochloric acid, since this yields a precipitate of potassium sulphate, which masks the final reaction. The final results are expressed by the number of milligrammes of potash (KHO which saponify 1 gm. of fat. Dr. Koettstorfer found that the amounts of potash necessary for various fats were as follow:—

[illegible]

[illegible] low:—

1 gm.	butter-fat	required from	221·5 to 232·4	mgm. KHO
„	beef dripping	„	196·1 to 196·9	„
„	commercial tallow	„	196·6 to 196·9	„
„	lard	„	195·1 to 196·1	„
„	mutton dripping	„	196·9 to 197·0	„
„	olive oil	„	191·5 to 192·2	„
„	colza oil	„	178·3 to 179·0	„

5°. **Hübl's Iodine Absorption Process.**—This method is stated by its author* to be based on the fact that nearly all fats are composed of the glycerin ethers of the members of three groups of fatty acids—viz., the *acetic, acrylic,* and *tetrolic* series. The relative proportion of these acids in any variety of fat or oil is *constant within certain limits*, and differs only in different *kinds* of oils, but the members of the three groups of acids exhibit a very different behaviour towards chlorine, bromine, or iodine. While under ordinary circumstances the acids of the acetic series are indifferent, those of the acrylic and tetrolic series readily unite with definite quantities of the halogens. If, therefore, it is possible to make a fat unite with a halogen, so that the amount of the latter which enters into the compound may be accurately determined, the number thus obtained would be a constant, and would be dependent upon the amount of unsaturated acids present in the fat. An alcoholic solution of iodine and mercuric chloride was found to give better results than iodine alone. HÜBL states that he prepares his standard solution by dissolving 25 gms. iodine and 30 gms. mercuric chloride, each in ½ litre of 95 per cent. alcohol, and uniting the two solutions. After standing from six to twelve hours, the strength of the solution is determined by means of a standard solution of sodium hyposulphite.

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* "Dingl. Polytechnisches J." 253, 281 ; "American Chem. Journ." Nov. 1884.

The following is the method of applying this test:—Weigh out 0·2 to 0·8 gm. of the oil or fat, and dissolve in 10 c.c. of chloroform. Add an excess of the above iodine solution, and, after standing for one and a-half to two hours, determine the excess of iodine by the sodium hyposulphite solution. By calculation, the number of grams of iodine taken up by 100 gms. of the oil is then found, and this number is the constant for the fat examined.

In connection with this method HÜBL recommends also the taking of the melting point of the free fatty acids.

The following are some of the instances in which the quantity of iodine per 100 gms. of oil has been determined: *—

	Iodine Degree.	
	HÜBL.	MÖLLER.
Shark-liver oil......	—	268·2
Manhaden ,, ...	—	170·8
Porpoise ,, ...	—	131·2
Seal ,, ...	—	103·4
Linseed ,, ...	158	175·7
Walnut ,, ...	143	—
Poppy-seed ,, ...	136	—
Cotton-seed ,, ...	106	107·9
Rape-seed ,, ...	100	99·4
Almond ,, ...	98·4	—
Castor ,, ...	84·4	—
Olive ,, ...	82·8	81·3
,, ,, (b)	—	102·9
Lard ,, ...	59	47·2
Palm ,, ...	51·5	48·6
Tallow ,, ...	40	—
Cocoa-nut ,, ...	8·9	6·8
Cocoa-butter	—	34·4
Muskat-butter	—	31·6
Mutton-fat	—	57·3
Lard	—	55·0
Beef-suet	—	38·4
Oleic acid...............	—	86·2

		Iodine Degree.	
		HÜBL.	MÖLLER.
Olein......................		—	82·3
Commercial stearin		—	1·7
Bees'-wax................		—	5·3
Japanese wax		4·2	5·61
Bayberry tallow		—	1·38
Butter		31	36·8
Oleomargarin		55·3	53·5
"Butter" (a).........		—	42·8
,, (b).........		—	43·0
,, (c).........		—	43·6
	%		
Oleomargarin Butter	43·71 56·29	—	43·52
Oleomargarin Butyric acid Butter	19·54 31·94 48·52	—	28·07
Olive oil ...... Cotton - seed oil............	68·24 31·76	—	88·54
Butter .... Oleomargarin Cotton - seed oil............	47·88 33·29 18·82	—	4·36

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* The "butters" marked (a), (b), and (c) contained 90 to 91 per cent. insoluble and 4·2 to 4·6 per cent. soluble fatty acids. "Olive oil" (b), though sold for genuine oil, was apparently (by this test) mostly cotton-seed oil. (Note.—Iodine absorptions × ·63 = bromine absorptions.)

Some of HÜBL's conclusions from his experiments* are the following:—

1. Linseed oil is distinguished by its high iodine degree, and any addition of a foreign oil must reduce that degree. (It will be seen from the table, however, that MÖLLER found a higher figure for shark-liver oil than he did for linseed oil.) By boiling linseed oil, its iodine degree is lowered, but the fusing point of its fatty acids is increased. (Compare its behaviour with bromine, p. 253.)

2. An addition of 5 to 10 per cent. of cotton-seed or rape-seed would be readily detected in nut or poppy oil, but not much less than 20 per cent. of linseed.

3. Rape-seed oil, as regards the iodine absorption, is affected by the method of extraction and refining. The refined oil usually has an iodine degree 2 or 3 degrees below that of the raw product. A falsification with 15 per cent. of linseed oil would be detected with certainty.

4. Castor oil possesses a very constant iodine degree—from 84·0 to 84·7, and is distinguished from all other oils and fats by this figure, by the points of fusion and solidification of its fatty acids (13° and 3° C. respectively), by the saponification test, and by its ready solubility in alcohol and acetic acid.

5. In twenty samples of olive oil, collected from various sources, the absorption of iodine varied only within 3 degrees. (It is important to notice that the degree for olive oil is confirmed by MÖLLER.) The addition of about 5 per cent. of a drying oil, or 15 per cent. of cotton-seed, sesamé, arachis, or rape-seed, may be established with certainty.

6. Animal fats, as is well known, are liable to alteration in respect of their consistency and proportion of oleic acid owing to variety, age, and food of the animal whence

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* "J. Soc. Chem. Ind." 1884, 642.

derived. In the case of butter-fat the absorption of iodine varies between the limits of 26 and 35.

7. When the nature of two fats in a mixture is known, their proportion may be determined approximately by the formula

$$x = \frac{100\,(I - n)}{m - n}$$

where x = the percentage of one fat
y = „ „ the other
I = iodine degree of the mixture
m = „ „ „ fat x
n = „ „ „ „ y

8. The age of a fat, so long as great alterations have not taken place, does not affect its iodine absorption. If, however, an oil has become rancid, and contains free acid, the iodine degree suffers considerable depression.

6°. **Mills' Bromine Absorption Process.**—This is described by Messrs. MILLS and SNODGRASS in "Journ. Soc. Chem. Ind." Nov. 5, 1883, and is an improvement on that first suggested by CAILLETET in 1857. The details are as follow:—

1. The substance is dried by heat, or by filtration through dry paper scrap (which is usually quite sufficient).

2. It is then dissolved in carbon disulphide, so as to make a solution of 10 per cent., or less strength.

3. A definite volume of this solution is then placed in a narrow-mouthed, stoppered bottle of 100 c.c. capacity, and diluted with more disulphide to about 50 c.c.

4. A deci-normal solution of bromine in carbon disulphide is then run in gradually, in successive portions, with agitation, until the colour of the *free bromine remains permanent for fifteen minutes.* During this operation, direct sunlight must be carefully avoided.

5. At the end of the fifteen minutes, to 50 c.c. of disul-

phide, in another exactly similar bottle, standard bromine is added until the tint in both bottles is the same. The number of cubic centimètres used in this blank experiment is then deducted from the number used in the absorption experiment, and the remainder gives the requisite datum for calculating the percentage of bromine added.

Tabular Statement of Absorptions obtained by above Process.[*]

Substance.	Absorption per cent.	Remarks.
Illuminating mineral oil (A) ...	27·57	S.G. ·8069
„ „ (B) ...	30·31	„ ·8045
Lubricating shale oil	22·24	„ ·860
„ „	20·59	„ ·870
„ „	12·59	„ ·890
„ „	11·72	„ ·900
Vaseline	5·55	American
Paraffin	0·52	Pale yell. M.P. 51·7°
Cocoa-nut oil	5·70	
Palm oil	34·79	Acid to litmus
Cotton-seed oil	49·97	
Olive oil	54·0	
Castor oil	58·34	Absorption rapid
Rape oil	69·43	Old sample
Linseed oil	76·09	
„ (boiled)	102·36	Made from above
Stearic acid	0·0	
Butter (from fresh cream)	27·93	Made in laboratory
„ (commercial)	24·49	
Butterine (Scotch ?)	36·32	
„ (French)	39·71	Marseilles
Beef fat..............................	35·01	
Lard	37·29	
Winter sperm	56·0	
Cod-liver oil	81·91	Absorption slow
Skate oil	123·5	Henry's unrefined Very slow absorption
„	109·2	Refined by filtration
Aniline................................	169·8	
Purified resin oil	40·69	Pine oil
Turpentine	255·0	Moist
„	236·0	Dry
„ (Russian)	220·7	Moist

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[*] "Jour. Chem. Ind." Nov. 29, 1883.

The authors prefer this colorimetric comparison at the end to titration for the sake of expedition. If, however, the operator should prefer the more exact method, he must transfer the carbon disulphide to a flask containing excess of aqueous potassic iodide, add a little starch solution, and decolorize with standard thiosulphate.

In considering the above results, the authors call attention to the following points :—

1. The absorption by paraffin oils increases as the sp. gr. diminishes.

2. Pure solid paraffin—*i.e.*, free from liquid oils—should exhibit no absorption ; hence the absorption is a useful measure of its more or less imperfect purification.

3. As regards cotton-seed and olive oils, the distinction is not so great as by MAUMENÉ's test.

4. Fish oils will all, probably, resemble cod oil by absorbing much bromine.

5. The fact that boiled linseed absorbs so much more bromine than the unboiled shows that the process of boiling implies de-hydrogenation.

6. In the case of cocoa-nut and palm oils, cod and skate oils, this method shows a striking difference.

7. There is a well-marked distinction between butter and its imitations or its allied fats (beef and lard). As the method is more readily applied than that of saponification, it may prove useful to public analysts, as well as to butterine manufacturers.*

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* During the discussion of this process, Mr. ALLEN stated he preferred what he called the "moist" bromine process to that of Messrs. MILLS and SNODGRASS. He takes a known quantity of the oil to be tested, and adds a known measure of a standard solution of sodium hypobromite and excess of dilute hydrochloric acid (for details, see p. 289). The decomposition of the hypobromite and consequent liberation of bromine occur in the aqueous layer, and hence the oil is not subjected to treatment with nascent bromine

Messrs. Mills and Akitt* describe an improvement of this process, which consists in substituting carbon tetrachloride for the bisulphide. The method is as follows:—

1. About 0·1 gm. of the oil is dissolved in 50 c.c. of the tetrachloride.

2. Standard bromine solution is added till at the end of fifteen minutes a permanent coloration remains.

3. This is compared with a coloration similarly produced in a blank experiment, and thus a measure of the bromine absorption is obtained, or it may be titrated in the ordinary manner by adding the solution of the brominated substance to potassic iodide with starch and sodic thiosulphate to this, or the converse. Or the excess of bromine may be titrated back in the same solvent by using β-naphthol as indicator. In presence of carbon tetrachloride β-naphthol forms a mono-bromo-derivative, and the indicator is made to correspond to the bromine solution in the ratio $Br_2 : C_{10}H_8O$.

The table on p. 255 exhibits some of the results obtained.

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at all, unless the momentary action at the point of contact of the two strata be so considered. The essential difference between Allen's method and the one above described is that the latter is performed in the absence of water. The following figures were obtained by the moist bromine process:—

Petroleum spirit	10·0	A. H. Allen.
Shale naphtha	94·9	
Howard's American turpentine oil	192·0	
English resin spirit	252·0	
Russian resin spirit	246·0	
Genuine turpentine oil	223·0 and 224·0	L. Archbutt.
Commercial " "	233·0 233·0 192·0 202·0 210·0 200·0	

* "Journ. Soc. Chem. Ind." June 29, 1884.

The average probable error of a single result is 0·62; where β-naphthol was used as an accessory this was reduced to 0·46. Mean strength of the standard bromine, ·00644 gm. per c.c.

Substance.	Absorption per cent.	Sp. gr. at 11°-12°.	Melting Point.	Remarks.
Almond oil	26·27	·9168	...	Expressed from bitter almonds
,,	53·74	·9154	...	,, ,, sweet ,, Yellower
Bees'-wax	0·54	...	63·9	English 1883. Very yellow
,,	0·00	...	63·2	Scotch 1876. Pale
,,	0·00	...	62·9	,, 1882. Yellow
,,	0·00	...	63·3	,, 1883. ,,
Ben oil	52·95	·9198	...	Much solid fat
,,	50·89	·9101	...	No solid fat
Carnauba wax	33·50	...	84·1	
Cod oil	83·12	·9269	...	1877. Scotch, rancid with age. One hour's absorption
,,	84·03	·9292	...	1882. Norwegian refined
,,	82·94	·9257	...	1882. Japanese
,,	81·61	·9277	...	1882. Scotch
,,	80·69	·9281	...	1883. Crude, from liver refuse
,,	83·01	·9318	...	1883. Norwegian
,,	82·07	·9278	...	1883. Scotch
Croton oil	46·66	·9441	...	Twenty hours' absorption
Eucalyptus oil	94·09	·8691	...	Fifteen minutes' absorption
Horse fat	35·67	...	...	Pasty, well mixed
Japan wax (I.)	2·33	...	50·5	
,, ,, (II.)	1·53	...	50·8	
Java-nut oil	30·24	...	...	
Ling-liver oil	82·44	·9295	...	1882. One hour's absorption
Maize-germ oil	74·42	·9262	...	1880.
Mustard-seed oil	46·15	·9152	...	East Indian
Myrtle wax	6·34	...	44·3	
Neat's-foot oil	38·33	·9147	...	Thick
Niger-seed oil	35·11	·9244	...	
Olive oil	59·34	·9266	...	Thick, brown, "best sulphocarbon"
,,	60·61	·9382	...	Thinner, greener, "low quality sulphocarbon"
Palm oil	35·44	...	...	Crude old Calabar
,,	34·96	...	...	,, Lagos
Peach-kernel oil	25·40	·9175	...	
Poppy oil	56·54	·9244	...	Turbid, filtered
Resin (common)	112·70	...	...	Light colour
Seal oil	57·34	·9241	...	Pale. One hour's absorption
,,	59·92	·9216	...	Dark
Sesamé oil	47·35	·9250	...	
Shark-liver oil	84·36	·9293	...	Dec. 1883. One hour's absorption
Sunflower oil	54·32	·9391	...	Colourless. About 1868
Whale oil	30·92	·9190	...	Norwegian white whale. Very thick
,,	48·69	·8780	...	"Bottle-nose whale"

Note.—Bromine absorptions × 1·5875 = iodine absorptions.

7°. **Reichert's Process for Butters.**[*]—The fat is dried and filtered through cotton-wool, 2·5 gms. are weighed in a liquid state into a flask of 150 c.c. capacity, and 1 gm. of solid potassium hydrate and 20 c.c. of 80 per cent. alcohol are added. The whole is heated on a water-bath, with constant shaking, until the soap is no longer a frothing, slimy mass; 50 c.c. of water are then added, and, as soon as the soap is dissolved, 20 c.c. of dilute sulphuric acid (1–10) are poured into the mixture and distilled, a slow stream of air being constantly passed to avoid bumping. A conical tube should be connected with the flask so as to prevent any sulphuric acid spirting over. If necessary, the distillate is filtered into a 50 c.c. flask through a wet filter-paper to separate solid fats. After about 15 c.c. have passed over, the distillate is poured back into the distillation flask, and the distillation is continued until exactly 50 c.c. are obtained. This distillate, which will be quite clear if the process has been slowly conducted, is mixed with 4 drops of litmus solution, and titrated with deci-normal soda solution. The process, according to the author, yields very constant results when repeated on different portions of the same sample. Any butter requiring less than 12·5 c.c. for this titration is considered adulterated. Cocoa-nut oil, lard, suet, and other adulterants of butter yielded distillates requiring from 3·7 to 0·25 c.c. only of soda solution.

Prof. CORNWALL has compared the methods of HEHNER, KOETTSTORFER, HÜBL, and REICHERT, and considers that, of these, the last is the most reliable process for butters.[†]

(2) ESSENTIAL OILS.

The essential or volatile oils of commerce are very frequently adulterated with the fatty oils, resins, spermaceti, or alcohol, or with other essential oils of a cheaper kind or lower grade.

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[*] "Zeitschr. Anal. Chem." 1879, 68–73; "J. Chem. Soc." 1879, 407.

[†] Report to the New Jersey State Board of Health for 1884.

Detection of Fatty Oils, Resins, or Spermaceti.—Place a drop of the suspected oil on a piece of white paper, and expose it for a short time to heat. If the oil is pure, it will entirely evaporate; but, if one of these adulterants is present, a greasy or translucent stain will be left on the paper. These substances also remain undissolved when the oil is agitated with thrice its volume of rectified spirit.

Detection of Alcohol.—1. Agitate the oil with a few small pieces of dried chloride of calcium. These remain unaltered in a pure essential oil, but dissolve in one containing alcohol, and the resulting solution separates, forming a distinct stratum at the bottom of the vessel. When only a very little alcohol is present, the pieces merely change their form, and exhibit the action of the solvent on their angles or edges, which become more or less obtuse or rounded.

2. Another test for alcohol in the essential oils is the milkiness occasioned by agitating them with a little water, as well as the loss of volume of the oil when it separates after repose for a short time.

3. M. Beral considers the following a more delicate test for alcohol than either of the preceding:—12 drops of the oil are placed on a perfectly dry watch-glass, and a piece of potassium, about the size of an ordinary pin's head, set in the middle of it. If the small fragment of metal retains its integrity for twelve or fifteen minutes, no alcohol is present; but if it disappears after the lapse of five minutes, the oil contains at least 4 per cent. of alcohol; and if it disappears in less than one minute, it contains not less than 25 per cent. of alcohol.

4. Boettger states that anhydrous glycerine possesses the property of dissolving in alcohol, without mixing with the volatile oils. The mode of applying the glycerine is as follows:—The oil to be examined is well shaken, in a gra-

duated tube, with its own volume of glycerine (sp. gr. 1·25). Upon being allowed to settle, the mixture separates into two layers. The denser glycerine separates rapidly, and if the essence has been mixed with alcohol this is dissolved in the glycerine, the augmentation in the volume of glycerine showing the proportion of alcohol.

5. If alcohol is present, a colorization is obtained when a few drops of the essential oil are poured on a granule or two of fuchsine or rosaniline. No change of colour is produced by pure oils.

This species of adulteration is very common, as it is a general practice of the druggists to add a little of the strongest rectified spirit to their oils to render them transparent, especially in cold weather. Oil of cassia is nearly always treated in this way.

Detection of Inferior Essential Oils.—1. The admixture of an inferior oil with one more costly may be detected by pouring a drop or two on a piece of porous paper or cloth, and shaking it in the air, when, if occasionally smelled, the difference of the odour at the beginning and the end of the evaporation will show the adulteration, especially if the added substance is turpentine.

2. Another method for the detection of turpentine, is based upon its power of dissolving fats:—Take about 50 grs. of oil of poppy in a graduated glass tube, and add an equal quantity of the sample of essential oil. Shake the mixture up thoroughly, and then allow it to stand. If the essential oil be pure, the mixture becomes milky, and does not clear until after several days have passed, whereas it will remain transparent if even so little as 5 per cent. of essence of turpentine be present.

3. ZELLER proposed alcohol as a means of detecting admixture with oil of turpentine. DRAGENDORFF applies this test in the following way:—The alcohol is first diluted

till 2–4 volumes of it are required to dissolve 1 volume of the oil. It will then be found that the presence of a small quantity of turpentine is indicated by the decreased solubility of the adulterated oil in the alcohol. 2 c.c. of the sample are placed in a stoppered bottle, and the diluted alcohol is then added from a burette, shaking after each addition. It will be found that a larger proportion of alcohol will be required to produce a clear liquid in the bottle in a sample containing turpentine than in a pure oil.

4. Many of the more expensive oils are adulterated with sassafras oil, the presence of which, according to HAGER, may be easily detected by mixing the sample with sulphuric acid and diluting the mixture with alcohol, when a cherry-red colour is produced if sassafras oil has been added.

5. The adulteration of a heavy oil with a light one, or the reverse, may be detected by agitating the suspected oil with water, when in many cases the two will separate and form distinct strata.

The purity of essential oils may likewise, in many cases, be determined by taking their sp. gr.; or, with still greater accuracy and convenience, by measuring their index of refraction, as suggested by Dr. WOLLASTON. A single drop of oil is sufficient for the application of the last method. (For Table of Refractive Indices, *see* p. 271.)

Cohesion Figures.—Miss CRANE believes that the cohesion figures afforded by the volatile oils, like those of the fixed ones, will be found useful indications of their purity. The application of her method is precisely similar to that followed in her examination of the fixed oils as already described (*see* p. 216). She finds that—

Oil of Turpentine by itself spreads instantly to the whole size of the plate (a common soup-plate), and almost immediately the edge begins to break into irregular shapes, when a rapid motion takes place over the surface of the film, and there seems to be a contest between the cohesion of the oil particles and the adhesion between them and the water. The oil makes repeated efforts to gather itself closer together, when the water instantly reacts, giving a wavy appearance to the whole figure.

The play of colours at this point is beautiful, and serves to bring out the lines more perfectly. In a few seconds innumerable little holes appear over the surface, which soon are separated only by threaded lines, and the figure is like the most exquisitely fine lace.

Oil of Cinnamon forms a figure not more than half the size of the last-named. In a few seconds small portions are detached, and shortly separate into distinct drops, four or five larger and a number of smaller ones scattered about. With mixtures in different proportions of *oil of turpentine* the figures formed differently, taking more of the characteristics of the adulterant as it predominated.

Oil of Nutmeg forms a large figure instantly, the edge showing a beaded line. It gathers itself together and spreads again, very like oil of turpentine, but the surface presents more the appearance of watered silk. Within sixty seconds some holes appear, and in eighty more the surface is covered with them. These scarcely spread to more than a sixteenth of an inch in diameter, but from the first each is bordered with a dotted edge. The figure lasts some time without changing materially, except that the openings lengthen out into an oblong shape, remaining entirely distinct. The play of colours is very fine. With the addition of one-third of the *oil of turpentine*, the first spreading is little different, but openings appear in half the time, and the dotted border does not come as soon; in about four minutes the figure is most characteristically marked, and soon breaks up entirely, this being the distinctive difference between the pure oil and the mixture.

Oil of Peppermint spreads instantly to a large figure, and in ten or fifteen seconds openings appear, which increase rapidly in size. At first they look somewhat like the last-named, but are not nearly so numerous, and the border soon is more like tiny drops. In one and a half or two minutes they begin to run together, and the figure breaks up.

With the addition of *turpentine oil* the figure forms more slowly, and the breaking up is less rapid, but in five minutes the outlines only remain.

Oil of Bergamot spreads instantly. In thirty seconds tiny openings appear, not very abundant, and increase in size slowly. In five minutes they are not larger than *oil of nutmeg* at one and a half minute. At first they have a dotted border, but as they increase in size this changes to a scalloped film, which spreads until, in eight or ten minutes, they are joined together over the whole surface. This, with the *turpentine oil*, gives a watered surface in spreading, much more marked, and with a fine play of colours.

Forney's Iodine Pentabromide Test.—FORNEY[*] states that he applied this test by placing 5 or 6 drops of the volatile oil on a watch-glass and adding 1 drop of the pentabromide. This reagent, IBr_5, was prepared by dissolving 127 grs. of iodine in 400 grs. of bromine. All the oils used were of best quality, and pure. Corresponding experiments were performed also with the same oils previously mixed with 25 per cent. of oil of turpentine and the same proportion of 95 per cent. alcohol. The following table (pp. 262, 263) shows the results, and, it will be observed, exhibits an increased reaction with oil of turpentine and a less intense one with alcohol.

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[*] "Amer. Journ. Pharm." 1882, 546; "Year-Book of Pharmacy," 1883, 154.

Action of Iodine Pentabromide on Volatile Oils.

Oils.	Pure Oils.		Oils + 25 per cent. Oil of Turpentine.		Oils + 25 per cent. Alcohol.	
	Reaction.	Colour.	Reaction.	Colour.	Reaction.	Colour.
Almond, bitter	None	Orange red	Slight reaction and sputtering	Brownish yellow	None	Orange red
Amber, rectified	Slight	Cloudy green dark precipitate	Brisk eff.; slight sputtering	Brown red	Slight effervescence	Cloudy olive; black precipitate
Anise	Violent; sputtering	Brown red	Very violent	Yellowish brown	Brisk; slight eff. and sputtering	Brown red
Bay	Violent; brisk effervescence; sputtering	Brownish green	Ditto	Colourless, or yellowish	Ditto	Olive green
Bergamot ...	Ditto	Olive green	Ditto	Brownish, then greenish yellow	Ditto	Brownish
Camphor......	Ditto	Brownish red	Ditto	Brownish red	Brisk eff.	Brown red
Caraway......	Ditto	Greenish yellow	Ditto	Reddish brown	Slight eff.	Cloudy, brownish yellow
Cassia.........	Slow; slight effervescence	Greenish brown	Brisk effervescence	Cloudy; blackish brown	Ditto	Yellowish to greenish brown
Cinnamon (Ceylon)	Violent; brisk eff.; sputtering	Cloudy, blackish brown	Very violent	Olive green, then greenish black	Ditto	Brown red
Cloves.........	Ditto	Brown sediment	Ditto	Dark brown	Brisk; slight eff.	Cloudy yellow
Copaiba	Slight gentle effervescence; green vapours	Green	Brisk effervescence; green vapours	Brownish, then olive green; black precipitate	Slight green vapours	Green
Croton.........	None	Greenish yellow	Brisk eff.	Brown red	None	Cloudy, yellow
Cubebs	Violent; brisk eff.; sputtering	Greenish yellow; dark green on stirring	Very violent	Cloudy, inky, then clear olive green	Like pure oil	Dark to light green
Fennel	Ditto	Brown red	Ditto	Dark brown	Slight eff.	Red brown

Hemlock......	Ditto	Brownish yellow	Ditto	Brownish yell	Brisk: slight eff.; sputtering	Cloudy, yellowish brown
Horsemint ...	Ditto	Brownish red	Ditto	Straw yellow	Brisk eff.	Brownish red
Juniper	Ditto	Green; black precipitate	Ditto	Sea green	Brisk; slight eff. and sputtering	Green and brown layers; after mixing, dark green
Lavender ...	Ditto	Greenish brown	Ditto	Greenish brown	Brisk; slight eff.	Yellowish brown
Lemon	Ditto	Brownish yellow	Ditto	Cloudy, dark yellow	Brisk; slight eff.; sputtering	Yellow and brown layers—not miscible
Orange	Ditto	Black precipitate	Ditto	Cloudy, dirty violet, then clear, dark yellow	Ditto	Brownish yellow, brown precipitate
Pennyroyal...	Ditto	Cloudy, blackish brown	Ditto	Dark brown	Like pure oil, less sputtering	Dark brown
Peppermint...	Ditto	Ditto	Ditto	Cloudy, purplish black, then blue black and inky green	Brisk; slight eff.; sputtering	Bright green, then cloudy
Pimento	Ditto	Greenish brown	Ditto	Greenish brown	Ditto	Cloudy, greenish brown
Rosemary ...	Ditto	Reddish brown	Ditto	Reddish brown	Like pure oil	Reddish brown
Sassafras ...	Ditto	Yellowish, then light grey	Ditto	Reddish yellow	Ditto	Light brown
Savin	Ditto	Greenish brown	Ditto	Greenish brown	Brisk; slight eff. and sputtering	Cloudy, yellowish brown
Spearmint ...	Ditto	Brownish yellow	Ditto	Reddish brown	Ditto	Brownish yellow
Spruce	Ditto	Dark brown	Ditto	Ditto	Ditto	Light brown
Tansy	Ditto	Brownish yellow, then colourless	Ditto	Reddish yellow	Ditto	Yellow and red layers—not miscible
Wintergreen	Slight; gentle effervescence	Reddish brown	More active than pure oil	Straw	Slight effervescence	Cloudy yellow

COLOUR REACTIONS OF ESSENTIAL OILS.*

I. Bromine in Chloroform (1 to 20; 10 to 15 drops of the reagent to 1 drop of oil).

1°. *Colourless.*

Turpentine
Caraway
Lemon
Coriander
Cardamoms

2°. *Yellow.*

Bergamot
Bitter orange
Neroli

3°. *Changing to green.*

Cloves
Ginger
Lavender
Cajuput
Cascarilla

4°. *Changing to greenish-blue.*

Juniper
Pepper
Galanga

5°. *Changing to greenish-brown or brown.*

Sweet marjoram
Dill
Cumin
Valerian

6°. *Changing to rose, red, or reddish-violet.*

Rosemary
Fennel
Anise
Star anise
Cinnamon
Nutmeg
Thyme
Peppermint
Myrrh
Parsley

7°. *Changing to brownish-violet.*

Mace

8°. *Changing to blue or bluish-violet.*

Cubebs
Copaiba
Amomum
Laurel
Sandal-wood
Sweet flag

9°. *Changing to orange.*

Worm-seed
Cedar-wood
Camphor

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* DRAGENDORFF, "Pharm. Journ." [3] vi. 681 and 721; DRAGE DORFF's "Plant Analysis," translated by GREENISH.

II. **Chloral Hydrate** (**impure**).—2 drops of the reagent are applied to 1 drop of the oil. The chloral is recommended by Dragendorff to be prepared by saturating 100 c.c. of alcohol with chlorine, mixing with sulphuric acid (after partially separating the hydrochloric acid by evaporation), and distilling the resulting metachloral.

1°. *Changing to red, or reddish.*

Lemon
Bergamot
Cloves (on warming
Mace

2°. *Changing to reddish-violet.*

Pepper
Myrrh

3°. *Changing to dark-green.*

Copaiba

4°. *Changing to green, or greenish.*

Valerian
Cumin
Cinnamon (with violet margin).

The other oils give with chloral similar colours to those produced by solution of bromine in chloroform.

III. **Alcoholic Hydrochloric Acid.**—Both concentrated and dilute acid were used by the author. With the concentrated solution the colour reaction commenced immediately, but passed away rapidly; with the dilute solution the commencement and passing away were less rapid, whilst the colour was less intense, but in some cases the colour was purer. In the following cases 15 to 20 drops of the dilute acid (strength not stated) were used to 1 drop of oil:—

1°. *Colourless.*

Turpentine
Caraway
Coriander
Cardamoms
Cloves
Rosemary

2°. *Yellow.*

Bergamot
Mace
Dill
Bitter orange
Cumin

3°. *Brownish-red.*

Cascarilla
Lavender
Sweet marjoram
Worm-seed
Juniper

4°. *Rose, changing to deep red, or reddish-violet.*

Cubebs
Pepper
Copaiba
Cedar-wood
Cinnamon
Nutmeg
Thyme
Laurel
Sweet-flag
Myrrh

5°. *Red, changing to blue.*

Peppermint

IV. Concentrated Sulphuric Acid.—This test was performed by placing 2 drops of acid with 1 drop of oil in a watch-glass. The results were as follow:—

1°. *Brown, changing to fine red.*

Caraway
Sweet marjoram
Star anise
Mace
Dill
Juniper
Cubebs
Copaiba
Sage
Wintergreen
Lavender
Amomum
Cascarilla
Nutmeg
Thyme
Sandal-wood
Peppermint
Myrrh
Parsley
Gaultheria

2°. *Changing to violet.*

Cardamoms
Cloves
Fennel
Anise
Cajuput
Laurel

3°. *Green, changing to blue (at edges).*

Cinnamon

V. Fröhde's Test (1 c.c. concentrated sulphuric acid with 0·01 gm. molybdate of soda).—This reagent was used in a similar manner to the last, treating 1 drop of the oil with 3 drops of the test. The resulting colours were similar to those with sulphuric acid alone, but in most cases were more quickly produced, and were purer and more elegant.

VI. Fuming Nitric Acid.—3 to 5 drops of the acid were mixed with 1 drop of the oil in a test-glass.

1°. *Blood-red.*
Mace
Nutmeg
Pimento

2°. *Green.*
Cubebs

3°. *Bluish-violet.*
Copaiba

4°. *Reddish-violet.*
Myrrh

5°. *Violet.*
Pennyroyal

6°. *Cherry-red.*
Gaultheria

7°. *Carmine.*
Cinnamon

VII. **Picric Acid.**— 5 to 10 drops of the oil are brought into contact with 0·05 gm. of powdered picric acid. Many of the oils readily dissolve this in the cold, while others do so with heat and then only with difficulty. The solutions are at first yellow, but, by standing or heating, the different oils more or less quickly acquire another colour. Some of the solutions after standing re-deposit crystals.

1°. *Dissolve picric acid in the cold.*
Caraway
Cardamoms
Cloves
Rosemary
Sweet marjoram
Anise
Star anise
Dill
Valerian
Cumin
Gaultheria
Cinnamon
Sweet-flag

2°. *Deposit crystals on standing.*
Turpentine
Lemon
Bergamot
Sweet marjoram
Mace
Dill
Galangal
Bitter orange
Worm-seed
Valerian
Cedar-wood
Lavender
Cajuput
Nutmeg
Thyme
Laurel
Sandal-wood

3°. *Changing to orange.*
Cloves
Sweet marjoram
Anise
Star anise
Nutmeg
Cinnamon
Cumin
Amomum
Thyme

4°. *Changing to blood-red.*
Fennel
Myrrh

5°. *Changing to brown.*
Dill
Cascarilla
Galangal
Worm-seed (reddish-brown)
Sweet-flag (deep-brown)

6°. *Changing to green.*
Peppermint

Estimation of Volatile Oils.—The following method is given by O. OSSE:[*]—The oil is dissolved in petroleum spirit, distilling below 40° C., and evaporated in a watch-glass in a current of carefully dried air, until nearly every trace of petroleum spirit is removed. It is then left to evaporate spontaneously in the open air, and weighed at the end of every minute. When the loss in weight in one minute becomes constant, this loss is considered to represent the "evaporation constant," from which the weight of the oil obtained is corrected. This correction is effected by adding to the weight of the oil, when the loss in weight becomes constant, the amount of the constant loss multiplied by the number of minutes during which the oil has been previously allowed to evaporate in the open air. The method is applicable to the determination of the percentage of volatile oils in the aromatic waters of pharmacy, and of the solubility of these oils in water.

In the presence of resinous or fatty substances, after the total amount of the mixed volatile oil and resinous or fatty substance has been determined as above, the weight of this last can be found by heating the whole to 110° C. for an hour or two to drive off all the volatile oil.

Another way is to agitate the water containing the volatile oil with ether. On subsequent evaporation of the ethereal solution, the greater part of the oil is left behind.[†] Or, half an ounce of the liquid may be mixed with a small quantity of gelatinous starch, and a solution of iodine (1 gr. iodine in 500 grs. alcohol + 1500 grs. of water) added, with agitation, till the oil ceases to give up hydrogen to the iodine, and consequently the iodine begins to impart a blue colour to the starch. It must be noted, however, that different oils destroy the bluing power of different quantities of iodine (comp. HÜBL's test, p. 248), and that therefore this mode of testing can be applied only for comparing different samples of the same kind of aromatic water with each other.

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[*] "Arch. Pharm." [3] vii. 104.

[†] SOUBEIRAN, "J. Pharm." xvii. 620

Langbeck's Salicylic Acid Test.*—LANGBECK finds that salicylic acid is soluble in certain proportions in essential oils, and that the degree of solubility varies with the composition of the latter, those oils richest in oxygen dissolving it more readily than others, and from the relative capacity of an oil to dissolve salicylic acid the author draws his conclusions. He states that the most common adulterations consist in the admixture of from 5 to 10 per cent. of oil of turpentine. He therefore mixed several essential oils of known quality with various proportions of oil of turpentine, and gives the results in the tabular form shown on p. 270.

Another method of applying the above test was as follows:—A number of flat-bottomed reagent glasses, about 2 inches long and $\frac{5}{16}$ inch in diameter, were each charged with 0·05 gm. of salicylic acid, and then accurately weighed. Various oils, known to be pure, were next added, drop by drop, to the separate portions of salicylic acid. Each glass was then shaken, oil being added till a clear solution was obtained; the increments of weight now gave the comparative solubilities.

Langbeck's Iodide of Potassium Starch-paper Test.—LANGBECK states (*loc. cit.*) that all the essential oils as offered in the market contain traces of water, from the process of distillation, which gradually causes the formation of hydrogen peroxide, and to determine approximately the amount of the latter, and, consequently, the age of an oil, he employs iodide of potassium starch-paper, prepared by saturating bibulous paper with a mixture containing 2·0 gms. of potassium iodide to 1·0 gm. starch.

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* "Chem. Zeitung," 1884; "Chemist and Druggist," 1884, 461.

Oil.	No. of c.c. of Oil required to dissolve 1 gm. Salicylic Acid.	Remarks.
Aniseed	74·7	Freshly rectified
„	94·0	„ „ + 5 °/₀ oil of turpentine
„	116·0	„ „ + 10 „ „
„	70·0	1½ year old
„	81·0	„ + 5 „ „
„	100·6	„ + 10 „ „
Bergamot ...	30·0	Fresh
„	36·0	„ + 5 „ „
„	42·0	„ + 10 „ „
„	17·0	1 year old
„	22·5	„ + 5 „ „
„	36·0	„ + 10 „ „
Cajuput	10·0	„
Caraway ...	8·5	„
Cloves	56·0	Fresh
„	68·0	„ + 5 „ „
Cassia	7·7	1 year old
Lemon	80·0	½ year old
„	104·0	„ + 5 „ „
„	125·0	„ + 10 „ „
Eucalyptus ...	13·0	1 year old
Fennel.........	31·0	„
Juniper-wood	130·0	„
Lavender......	12·0	Fresh
Mint	10·0	2 years old
Peppermint...	7·0	
„ ...	14·6	+ 5 „ „
„ ...	26·0	+ 10 „ „
Thyme...	55·0	Fresh
Mustard	58·0	„
Valerian	15·0	3 years old
Turpentine ...	625·0	Fresh
„ ...	540·0	3 months old

The sample of oil to be examined is shaken up with its equal volume of distilled water, and the iodide of potassium starch-paper is then moistened with the latter. Fresh oils

Specific Gravities and Optical Properties of Essential Oils.

Crude Oils.	Sp. gr. at 15·5° C.	Refractive Indices.				Rotation.
		Temp. C.	A.	D.	H.	
Anise	0·9852	16·5°	1·5433	1·5566	1·6118	− 1°
Bay	0·8808	18·5	1·4944	1·5022	1·5420	− 6
Bergamot	0·8825	22	1·4559	1·4625	1·4779	+ 23
" Florence	0·8804	26·5	1·4547	1·4614	1·4760	+ 40
Birch-bark	0·9005	8	1·4851	1·4921	1·5172	+ 38
Cajuput	0·9203	25·5	1·4561	1·4611	1·4778	0
Calamus	0·9388	10	1·4965	1·5031	1·5204	+ 43·5
Caraway	0·8845	19	1·4601	1·4671	1·4886	+ 63
" Hamburg 1st dist.	0·9121	10	1·4829	1·4903	1·5142	...
" " 2nd dist.	0·8832	10·5	...	1·4784	...	...
Cascarilla	0·8956	10	1·4844	1·4918	1·5158	+ 26
Cassia	1·0297	19·5	1·5602	1·5748	1·6243	0
Cédar	0·9622	23	1·4978	1·5035	1·5238	+ 3
Cedrat	0·8584	18	1·4671	1·4731	1·4952	+156
Citronella	0·8908	21	1·4599	1·4659	1·4866	− 4
" Penang	0·8847	15·5	1·4604	1·4665	1·4875	− 1
Cloves	1·0475	17	1·5213	1·5312	1·5606	− 4
Coriander	0·8775	10	1·4592	1·4652	1·4805	+ 21?
Cubebs	0·9414	10	1·4953	1·5011	1·5160	...
Dill	0·8922	11·5	1·4764	1·4834	1·5072	+206
Elder	0·8584	8·5	1·4686	1·4749	1·4965	+ 14·5
Eucalyptus amygdalina	0·8812	13·5	1·4717	1·4788	1·5021	−136
" oleosa	0·9322	13·5	1·4661	1·4718	1·4909	+ 4
Indian geranium	0·9043	21·5	1·4653	1·4714	1·4868	− 4
Lavender	0·8903	20	1·4586	1·4648	1·4862	− 20
Lemon	0·8498	16·5	1·4667	1·4727	1·4946	+164
Lemon-grass	0·8932	24	...	1·4705	...	− 3?
" Penang	0·8766	13·5	1·4756	1·4837	1·5042	0
Mint	0·9342	19	1·4767	1·4840	1·5015	−116
"	0·9105	14·5	1·4756	1·4822	1·5037	− 13
Myrtle	0·8911	14	1·4623	1·4680	1·4879	+ 21
Myrrh	1·0189	7·5	1·5196	1·5278	1·5472	−136
Neroli	0·8789	18	1·4614	1·4676	1·4835	+ 15
"	0·8743	10	1·4673	1·4741	1·4831	+ 28
Nutmeg	0·8826	24	1·4644	1·4709	1·4934	+ 44
" Penang	0·9069	16	1·4749	1·4818	1·5053	+ 9
Orange-peel	0·8509	20	1·4633	1·4699	1·4916	+ 32?
" Florence	0·8864	20	1·4707	1·4774	1·4980	+216
Parsley	0·9926	8·5	1·5068	1·5162	1·5417	− 9
Patchouli, Penang	0·9592	21	1·4980	1·5040	1·5183	−120
" French	1·0119	14	1·5074	1·5132	1·5202	...
Peppermint	0·9028	14·5	1·4612	1·4670	1·4854	− 72
" Florence	0·9116	14	1·4628	1·4682	1·4867	− 44
Petit-grain	0·8765	21	1·4536	1·4600	1·4808	+ 26
Rose	0·8912	25	1·4567	1·4627	1·4835	− 7
Rosemary	0·9080	16·5	1·4632	1·4688	1·4867	+ 17
Rosewood	0·9064	17	1·4843	1·4903	1·5113	− 16
Sandal-wood	0·9750	24	1·4959	1·5021	1·5227	− 50
Thyme	0·8843	19	1·4695	1·4754	1·4909	...
Turpentine (French?)	0·8727	13	1·4672	1·4732	1·4938	− 79
Verbena	0·8812	20	1·4791	1·4870	1·5059	− 6
Wintergreen	1·1423	15	1·5163	1·5278	1·5737	+ 3
Wormwood	0·9122	18	1·4631	1·4688	1·4756	...

give no coloration; while older oils yield a stain in proportion to their age.

Volatile oils possess great refractive and dispersive power, and exhibit great diversity in their action on polarized light, some being dextro-, others lævo-rotatory in very various degrees, while a few are inactive. The table on p. 271 exhibits the rotatory power of a considerable number, together with their refractive indices for the lines A, D, and H, as determined by GLADSTONE,* and also their specific gravities. The rotatory power was determined for a column of liquid 10 inches long; the same length of a solution of equal parts of cane-sugar and water produced a deviation of + 105°.†

(3) MINERAL OILS.

Directions for Testing Petroleum to ascertain the Temperature at which it gives off Inflammable Vapour.

The Sanitary Commission of the "Lancet" took as the limit of safety an oil that gave off inflammable vapour when heated to 130° F., and this was generally accepted by dealers. If an oil gave off inflammable vapours before being heated up to 130°, it was considered unsafe for domestic use.

1. The plan for testing this recommended in the "Lancet" was to heat a portion of the suspected oil in a gallipot placed in boiling water, and to ascertain, by a thermometer suspended in the oil, the temperature at which it would take fire on the surface when a lighted wax vesta was applied to it. It was a troublesome and dangerous process, and of little practical value.

2. A rough-and-ready method of testing the inflammability of a sample is to pour a little out on a dry flat

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* "Chem. Soc. J." xvii. 3.

† WATTS' "Dictionary of Chem." iv. 185, 186.

board, and try whether it can be ignited readily by a lighted paper. If it catches fire like turpentine or brandy, the oil is dangerous:—

3. The following plan, proposed by Mr. TEGETMEIER, requires no scientific knowledge and no apparatus but what is to be found in every house, while it is sufficiently accurate to enable any one to find out whether or not a sample is dangerous:—

"Take an earthenware vessel, holding about half a pint (a breakfast-cup will do), fill it with boiling water, pour this into an earthenware quart jug, then fill the cup again with boiling water, and pour it also into the quart jug. Cool this by mixing with it half the quantity of cold water, and pour the resulting tepid water from the jug into the cup till the latter is half full. Now pour about a tablespoonful of the oil to be tested on the tepid water, take the oil-can with the oil out of the room, and touch the surface of the oil in the cup with a lighted splinter of wood, or a match without sulphur. If the match causes a flash of flame to appear on the surface, the oil is below the standard of safety, and should not be used; if no flame appears, the oil is up to the standard. In this trial no time should be lost after pouring the boiling water from the kettle, as the water may get too cold, but the whole may be gone through in from two to three minutes. It is well to have a saucer at hand, and if the oil should be an unsafe one, and ignite with the match, the flame may be extinguished by placing the saucer on the mouth of the cup. This test should be done by daylight, at a distance from a fire, and the above directions should be exactly followed." (*See* "AMERICAN 'FIRE TEST,'" p. 280.)

In 1862 the term "petroleum" was defined by the Act 25 & 26 Vict. c. 66 to include "any product thereof which gives off an inflammable vapour at less than 100° F.," and what was known as the "open test," for determining this "flashing" point, was legalized by the Petroleum Act of 1871 (34 & 35 Vict. c. 105). Many objections were raised as to the uncertainty of this method, and in 1879 the Act 42 & 43 Vict. c. 47, was passed, which substituted the "close" test for the "open" one. As this reduced the flashing point many degrees, the standard temperature of 100° F. of the former Act was reduced to 73° F. in the new Act.

MODE OF TESTING PETROLEUM

Prescribed by the Petroleum Act, 1879, so as to ascertain the Temperature at which it will give off Inflammable Vapour.

Specification of the Test Apparatus.—The following is a description of the details of the apparatus :—

The oil-cup consists of a cylindrical vessel 2 inches in diameter, $2\frac{2}{10}$ inches in height (internal), with outward projecting rim $\frac{5}{10}$ inch wide, $\frac{3}{8}$ inch from the top, and $1\frac{7}{8}$ inch from the bottom of the cup. It is made of gun-metal or brass (17 B.W.G.) tinned inside. A bracket, consisting of a short stout piece of wire bent upwards and terminating in a point, is fixed to the inside of the cup to serve as a gauge. The distance of the point from the bottom of the cup is $1\frac{1}{2}$ inch. The cup is provided with a close-fitting overlapping cover made of brass (22 B.W.G.), which carries the thermometer and test-lamp. The latter is suspended from two supports from the side by means of trunnions upon which it may be made to oscillate, it is provided with a spout, the mouth of which is $\frac{1}{16}$ inch in diameter. The socket which is to hold the thermometer is fixed at such an angle and its length is so adjusted that the bulb of the thermometer when inserted to its full depth shall be $1\frac{1}{2}$ inch below the centre of the lid.

The cover is provided with three square holes, one in the centre, $\frac{5}{10}$ by $\frac{4}{10}$ inch, and two smaller ones, $\frac{3}{10}$ by $\frac{2}{10}$ inch, close to the sides and opposite each other. These three holes may be closed and uncovered by means of a slide moving in grooves, and having perforations corresponding to those on the lid.

In moving the slide so as to uncover the holes, the oscillating lamp is caught by a pin fixed in the slide, and tilted in such a way as to bring the end of the spout just below the surface of the lid. Upon the slide being pushed back so as to cover the holes, the lamp returns to its original position.

Upon the cover, in front of and in line with the mouth of the lamp, is fixed a white bead, the dimensions of which represent the size of the test-flame to be used.

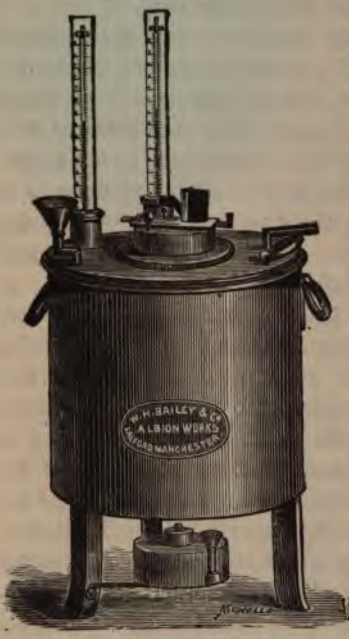
The bath or heated vessel consists of two flat-bottomed copper cylinders (24 B.W.G.), an inner one of 3 inches diameter and 2½ inches height, and an outer one of 5½ inches diameter and 5¾ inches height; they are soldered to a circular copper plate (20 B.W.G.) perforated in the centre, which forms the top of the bath in such a manner as to enclose the space between the two cylinders, but leaving access to the inner cylinder. The top of the bath projects both outwards and inwards about ⅜ inch; that is, its diameter is about $\frac{6}{8}$ inch greater than that of the body of the bath, while the diameter of the circular opening in the centre is about the same amount less than that of the inner copper cylinder. To the inner projection of the top is fastened, by six small screws, a flat ring of ebonite, the screws being sunk below the surface of the ebonite, to avoid metallic contact between the bath and the oil-cup. The exact distance between the sides and bottom of the bath and of the oil-lamp is half an inch. A split socket similar to that on the cover of the oil-cup, but set at a right angle, allows a thermometer to be inserted into the space between the two cylinders. The bath is further provided with a funnel, an overflow pipe, and two loop handles.

The bath rests upon a cast-iron tripod stand, to the ring of which is attached a copper cylinder or jacket (24 B.W.G.)

flanged at the top, and of such dimensions that the bath, while firmly resting on the iron ring, just touches with its projecting top the inward-turned flange. The diameter of this outer jacket is 6½ inches. One of the three legs of the stand serves as support for the spirit-lamp attached to it by means of a small swing bracket. The distance of the wick-holder from the bottom of the bath is 1 inch.

Two thermometers are provided with the apparatus, the one for ascertaining the temperature of the bath, the other for determining the flashing point. The thermometer for ascertaining the temperature of the water has a long bulb and a space at the top. Its range is from about 90° to 190° F. The scale (in degrees of Fahrenheit) is marked on an ivory back fastened to the tube in the usual way. It is fitted with a metal collar, fitting the socket, and the part of the tube below the scale should have a length of about 3½ inches measured from the lower end of the scale to the end of the bulb. The thermometer for ascertaining the temperature of the oil is fitted with collar and ivory scale in a similar manner to the one described. It has a round bulb, a space at the top, and ranges from about

FIG. 6.



Abel's "Petroleum Oil" Tester.

55° to 150° F.; it measures from end of ivory back to bulb 2¼ inches.

NOTE.—A model apparatus is deposited at the Weights and Measures Department of the Board of Trade (see Fig. 6).

Directions for applying the Flashing Test.—1. The test apparatus is to be placed for use in a position where it is not exposed to currents of air or draughts.

2. The heating vessel or water-bath is filled by pouring water into the funnel until it begins to flow out at the spout of the vessel. The temperature of the water at the commencement of the test is to be 130° F., and this is attained in the first instance either by mixing hot and cold water in the bath, or in a vessel from which the bath is filled, until the thermometer which is provided for testing the temperature of the water gives the proper indication, or by heating the water with the spirit-lamp (which is attached to the stand of the apparatus) until the required temperature is indicated.

If the water has been heated too highly, it is easily reduced to 130° by pouring in cold water little by little (to replace a portion of the warm water) until the thermometer gives the proper reading.

When a test has been completed, this water-bath is again raised to 130° by placing the lamp underneath, and the result is readily obtained while the petroleum-cup is being emptied, cooled, and refilled with a fresh sample to be tested. The lamp is then turned on its swivel from under the apparatus, and the next test is proceeded with.

3. The test-lamp is prepared for use by fitting it with a piece of flat plaited candle-wick, and filling it with colza or rape oil up to the lower edge of the opening of the spout or wick-tube. The lamp is trimmed so that when lighted it gives a flame of about 0·15 inch in diameter, and this size of flame, which is represented by the projecting white bead

on the cover of the oil-cup, is readily maintained by simple manipulation from time to time with a small wire trimmer.

When gas is available, it may be conveniently used in place of the little oil-lamp, and for this purpose a test-flame arrangement for use with gas may be substituted for the lamp.

4. The bath having been raised to the proper temperature, the oil to be tested is introduced into the petroleum-cup, being poured in slowly until the level of the liquid just reaches the point of the gauge which is fixed in the cup. In warm weather the temperature of the room in which the samples to be tested have been kept should be observed in the first instance, and if it exceeds 65° the samples to be tested should be cooled down (to about 60°) by immersing the bottles containing them in cold water, or by any other convenient method. The lid of the cup, with the slide closed, is then put on, and the cup is placed into the bath or heating vessel. The thermometer in the lid of the cup has been adjusted so as to have its bulb just immersed in the liquid, and its position is not under any circumstances to be altered. When the cup has been placed in the proper position, the scale of the thermometer faces the operator.

5. The test-lamp is then placed in position upon the lid of the cup, the lead-line or pendulum, which has been fixed in a convenient position in front of the operator, is set in motion, and the rise of the thermometer in the petroleum-cup is watched. When the temperature has reached about 66° the operation of testing is to be commenced, the test-flame being applied once for every rise of one degree, in the following manner:—

The slide is slowly drawn open while the pendulum * per-

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* The length of the pendulum is 2 feet from the point of suspension to the centre of gravity of the weight.

forms three oscillations, and is closed during the fourth oscillation.

NOTE.—If it is desired to employ the test apparatus to determine the flashing points of oils of very low volatility, the mode of proceeding is to be modified as follows:—

The air-chamber which surrounds the cup is filled with cold water, to a depth of 1½ inch, and the heating vessel or water-bath is filled as usual, but also with cold water. The lamp is then placed under the apparatus, and kept there during the entire operation. If a very heavy oil is being dealt with, the operation may be commenced with water previously heated to 120°, instead of with cold water.

A slight modification of the above process is necessary when the test is applied in tropical climates.* Messrs. ABEL & REDWOOD found that a sample of petroleum which gave a flashing point of 73° F. when the test was made at common temperatures, flashed on the first application of the test-flame at 66° F. when the testing was conducted in an apartment heated to a tropical temperature. They found that the lower flashing point was due, at any rate very largely, to vapour disengaged prior to the first application of the test-flame. After trying various methods, they ultimately preferred to commence applying the flame at a temperature of 56° F. when the first experiment has furnished a flashing point below 73° F. The effect of this modification is to gradually remove the vapour disengaged in filling the cup in successive quantities too small to give a flash, each application of the test-flame determining a current of air through the upper part of the cup, and sweeping out a portion of its gaseous contents. The method is obviously open to the objection that it effects the removal of some small proportion of the most volatile constituents of the oil, and that, consequently, the character of the sample has sustained some alteration tending to raise its flashing point before the testing is actually commenced. This is, however, unavoidable, and must occur in tropical climates to some extent whenever a sample is subjected to any manipulation in the open air. The extent to which the flashing point is thereby affected is, however, unimportant in comparison with the value to be attached, from a commercial point of view, to the attainment of uniform results in the examination of cargoes of oils in different countries.

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* "Chem. News," May 2, 1884; "J. Soc.Chem. Ind." 1884, 318.

In addition to the above modification of the test, it is recommended that the trade should provide for the liability of some samples to exhibit, when tested in India, a flashing point as much as 3° lower than the flashing point recorded before shipment.

American "Fire Test."—In this test the oil is heated in an open vessel, and the temperature at which the surface actually inflames is noted. This gives a higher point than the flashing tests, a temperature of 120° F. corresponding to a flashing point of 100° F. by the "open" and to 73° F. by the "close" test.

Estimation of Colour.*—Formerly the colour of refined petroleum was estimated by comparing it with that of a standard sample, the two oils being contained in bottles of the same size. In 1870 Mr. ROBERT P. WILSON patented the chromometer now largely used by the trade. This instrument consists of two tubes arranged side by side and furnished at the lower end with a small mirror, by means of which light may be reflected upwards through them, each tube having a screw cap with glass centre. Above the upper end of the tubes is fixed a small box containing two pairs of prisms, and above this is an eye-piece. Coloured glass was also substituted by Mr. Wilson for the liquid standards previously employed. In using the apparatus, one of the two tubes is completely filled with the oil to be tested, and beneath the other tube is placed one of the standards, consisting of a disc of stained glass about the size of a shilling. The mirror is then adjusted so as to throw the light through the tubes, and, upon looking into the eye-piece, a circular field, divided down the centre, is seen, the halves being tinted to an extent corresponding with the colour of the oil and of the glass standard respectively. This instrument was, after trial, adopted in 1872 by the Petroleum Association, and is now in use in America and on the European continent, as well as in this country.

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* [illegible] "J. Soc. Chem. Ind." 1885, 76.

Fluorescence, or "Bloom."—This is a characteristic of mineral oils, and often enables their presence in vegetable oils to be detected. It may be observed in various ways: by placing a small quantity in a test-tube, and looking down upon the column against a dark background, or by smearing a drop on the blade of a knife, and observing the edges of the oily surface. If the sample is turbid, it should be filtered, and if very dark coloured, shaken up with animal charcoal and filtered, before making the observation. If any fluorescence is noticeable in a sample of a fatty oil, the presence of a mineral adulterant is indicated, and confirmation must be sought by the specific gravity, by the characteristic after-taste, by the smell on heating, and by the incompleteness of the saponification.

The fluorescence of mineral oils is destroyed by treatment with nitric acid, but the "bloom" may be afterwards restored by means of concentrated sulphuric acid.

Detection of Resin Oil.*—1. Resin oils being optically active, while mineral oils are inactive, mixture of resin oil with a mineral oil is indicated by the polariscope. If the oil to be examined is high coloured, it is prepared for testing by treatment with ferrocyanide of potassium and subsequent filtration.

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* E. Valenta, "Dingl. Polyt. J." 253, 418-421.

2. The presence of resin oil in a mineral oil is also shown by the increased solubility of the sample in glacial acetic acid. The following is the method of applying this test:—2 c.c. of the sample are treated with 10 c.c. of glacial acetic acid, and heated for five minutes in a loosely corked test-tube in a water-bath. The mixture is then filtered, and the middle part of the filtrate is collected apart. A weighed quantity of this is titrated with standard alkali, and the weight of glacial acetic acid is calculated. The difference in weight between that of the solution and the acid obtained by this titration gives the amount of oil contained in the former.

The following table gives the numbers which were obtained for the solubility of different mixtures of oils containing a known amount of resin oil:—

Amount (per cent. by vol.) of Resin Oil, sp. gr. 1·0023 in Mixture. Sp. gr. of Mineral Oil used, 0·9139.	Gms. at 50° C. dissolved by 10 c.c. Glacial Acetic Acid, sp. gr. 1·0562.
0	0·6056
25	0·7796
50	0·8816
75	1·3237
100	1·7788

The highest amount dissolved when pure mineral oil was used was 0·6056, so that any increase above this is indicative of admixture with resin oil. It is to be noted, however, that the quantity dissolved does not increase in proportion to the amount of the adulterant present, so that the method is not quantitative.

3. The differences in the iodine and bromine absorptions

of resin oil and mineral oils are also distinguishing features. By HÜBL's method (see p. 248) VALENTA found that mineral oils absorb only 140 mgms. of iodine per gram of oil, while resin oils range from 430 to 480 mgms.

4. It has been suggested that the presence of resin oil when mixed with mineral oils may be detected by fractional distillation. A quantity of the sample is to be distilled and separated into five equal fractions. If resin oil be present, the specific gravities of the fractions will be found to differ from those of corresponding fractions of pure oils.

Detection of Fatty Oils in Mineral Oils.*—The method recommended by LUX is founded upon the different behaviour of the fatty and mineral oils, when heated with potash, potassium, soda, or sodium. For instance, rape oil, when heated with potash or soda to a high temperature, saponifies—stirring or shaking promoting the reaction. At a temperature of 250° C. rape oil gelatinizes with potash or soda in five minutes; after fifteen minutes, the oil turns brown and solidifies to a buttery mass. On the other hand, mineral oils treated in the same way become darker, but do not alter their state of aggregation. A. *Preliminary Test:* Detection of larger quantities of fatty oils (about 10 per cent. or more). —To about 5 c.c. of the oil under examination in a test-tube is added a small piece of sodium hydrate, the liquid heated directly over the flame to boiling, and kept boiling for about one to two minutes. Larger quantities of fatty oil are detected by the peculiar empyreumatic smell given off, and by the solidification of the liquid on slightly cooling.

If a negative result is obtained, proceed as follows:—B. The detection of smaller quantities of fatty oils (2 per cent. or less).—Two medium-sized beakers are taken, of which the one can be pushed so far into the other as to leave a space of about 1–2 cm. between the two. Into the larger beaker is placed enough paraffin to bring its surface halfway up between the sides of the two beakers. The inside beaker is also filled with paraffin to the same height. A paraffin-bath constructed in this way cannot be over-heated. A thermometer hung in the inner beaker should be kept at about 200–210° C. Two test-tubes are now supplied with a few c.c. of the oil; to the one are added some shavings of potassium, to the other a stick of potassium hydrate, so that the latter stands about 1 cm. above the surface of the oil. The two test-tubes are placed in the bath, and the time noted, and after fifteen minutes they are taken out and allowed to cool. If the mineral oil contain as much as 2 per cent. fatty oil, solidification takes place in one of the two test-tubes, or, generally, in both, to a tough jelly.

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* "Zeitschr. f. Anal. Chem." 24, 2, 347; "Analyst," 1885, 169.

Detection of Mineral Oils in Fats.*—F. NITSCHE heats 10 gms. of the sample with 7 gms. of soda solution, 38° B., and 30 gms. 90 per cent. alcohol in a water-bath until the alcohol begins to boil, and he then adds slowly 40 gms. glycerine, 28° B. 10 c.c. of petroleum spirit is then added to the soap solution, which appears turbid if there is an appreciable quantity of mineral oil present, and the mixture is thoroughly shaken. The petroleum spirit dissolves the hydrocarbons, and separates easily and completely from the soap solution, which does not solidify at ordinary temperatures, owing to the presence of the added glycerine. On evaporating the petroleum spirit, the mineral oil remains behind.

For quantitative analysis it is more exact to saponify other 10 gms. of the fat, separate the fatty acids, titrate, and compare the quantity of alkali used with that required by the above glycerine soap, which has been washed with benzene, and decomposed by boiling with sulphuric acid.

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* "Dingl. Polyt. Journ." 251, 335; "J. Soc. Chem. Ind." 1884, 322.

Detection of Solar Oil in Petroleum.[*]—Commercial petroleum is said to have a density of from 0·795 to 0·804, solar oil from 0·830 to 0·870, so that a density of the sample higher than 0·804 points to the presence of solar oil. The boiling point of ordinary petroleum is said to range from 180° to 250° C. and that of solar oil between 240° and 300° C. When petroleum is treated with concentrated sulphuric acid, the oil remains colourless, and only the acid is coloured a light brown. If solar oil be thus treated, it becomes brown, and the acid a dark reddish-brown. On treating a mixture of petroleum and solar oil with acid, the colour of the oil is the more intense in proportion to the quantity of solar oil present. After some hours, the red-brown colour of the oil changes to violet-red, whilst the acid remains brown. Dr. HEPPE finds that this method is not very satisfactory if the petroleum has been badly purified and good solar oil mixed with it. He has therefore devised a method which he considers affords good results with American petroleum. The sample is treated with perfectly dry copper butyrate in powder. The salt dissolves, giving a bluish-green colour to the solution, which is now heated. If solar oil be present, a yellow colour is produced at 120° C., with separation of yellow flocks, the quantity being in proportion to the amount of the admixture. If this oil be absent, the solution remains green and clear, even at a temperature of 210° C. Upon cooling the solution, a yellowish-brown precipitate is at first thrown down, and upon this a second precipitate of a greenish-blue colour, the liquid above being a pale-yellow. The first precipitate is due to the solar oil, the second to the petroleum. When the sample is free from solar oil, the liquid above the precipitate due to petroleum is almost colourless. The copper butyrate employed was prepared from ordinary commercial butyric acid.

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[*] Dr. G. HEPPE, "Chemisch. Techn. Central-Anzeiger;" "J. Soc. Chem. Ind." 1884, 232.

Determination of Oil in Paraffin Scale.—Paraffin scale is deposited from the oils in which it is dissolved by cooling to a low temperature. It is crude solid paraffin. A method of determining the quantity of oil contained in it is described by Mr. BOVERTON REDWOOD.* A modification of the "Boomer" press is employed, the minute deflection of the cross-head being magnified by levers, and conspicuously exhibited on the scale. The sample of scale is placed in a shallow iron cup, between circular pieces of calico, cut to fit, and with a sufficient number of sheets of blotting-paper of similar size, above and below, to absorb the oil. The plunger of the press, accurately fitting the cup, is screwed down, the pressure applied being about 9 cwt. per square inch. Mercury-cups are provided in the plunger and bed-plate of the press for taking the temperature. The quantity of oil obtained varies with the temperature employed, the amount of pressure, the length of time the pressure is continued, and the quantity of material operated upon, in relation to the diameter of the press-cake. In his experiments Mr. REDWOOD operated at 60° F.—with an indicated pressure of 9 tons applied for five minutes. The following are some of the results obtained :—

Example.	Percentage of Oil.		
	1st Experiment.	2nd Experiment.	Difference.
1	6·68	6·64	0·04
2	4·42	4·32	0·10
3	14·36	14·46	0·10
4	13·48	13·48	0·00
5	4·51	4·52	0·01
6	11·84	11·76	0·08

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* "Journ. Soc. Chem. Ind." iii. 430.

Mr. **Watson Smith** determines the paraffin in oils as follows:—10 gms. are treated with 108 c.c. of concentrated sulphuric acid, and the whole heated in a water-bath. The mixture is then cooled, and poured into 500 c.c. of water, when, on standing, the paraffin separates out as a layer on the surface of water. It is carefully removed, dried between blotting-paper, and weighed.[*]

Estimation of Carbon Disulphide in Crude Naphthas.—Messrs. Holland and Harcourt Phillips[†] recommend the following process:—

1°. Into a piece of combustion-tube, about 12 inches long, sealed at one end, and drawn out at the other extremity so as to form a funnel, are introduced 2 c.c. of the naphtha to be tested; next, 5 c.c. of ferric chloride solution (240 gms. Fe_2Cl_6 in 1 litre); and, finally, 10 c.c. of strong ammonia. The tube is now carefully sealed and well shaken.

2°. The tube is wrapped in a cloth, and immersed in boiling water for an hour or so. By this means the sulphur of the ammonium sulphide formed is fixed as a metallic sulphide.

3°. At the expiration of about an hour, the tube is taken out, allowed to cool, and opened. The contents are transferred to a flask, of about 16 oz. capacity, and evaporated just to dryness. This may be done over a Bunsen flame with careful management.

4°. 20 c.c. of fuming nitric acid are now added all at once to the residue in the flask, and the whole is boiled nearly to dryness. As a rule the sulphur will be found to have been completely oxidized. Should this not be the case, a little more nitric acid will generally effect it. Hydrochloric acid is then added, and some water, and the solution is filtered.

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[*] "J. Soc. Chem. Ind." 1884, 10.

[†] *Ibid.* 295.

5°. The sulphuric acid in the filtrate is then determined as barium sulphate in the usual manner.

NOTE.—As it is not possible to get the whole of the ferrous sulphide, &c., out of the tube with water alone, it is best to use a little hydrochloric acid to which have been added a few crystals of potassium chlorate.

The authors tested the accuracy of the process by the following experiments:—

	Test Mixture made up Contained by Volume CS_2 per cent.	Found CS_2 per cent.
1	1·65	1·63
2	2·81	2·71
3	3·3	3·24
4	4·5	4·26
5	4·83	4·77
6	5·04	4·90
7	5·0	4·78
8	5·0	5·03
9	5·0	5·33

In two samples of ordinary crude naphthas 0·143 and 0·207 per cent. of disulphide were found.

It is admitted that the process may return as carbon disulphide any other sulphur compounds present.

Action of Bromine on Shale and Petroleum Products.*—One of the best known and most characteristic of the properties of the olefines, or hydrocarbons of the ethylene series, is the readiness with which they enter into combination with bromine to form additive compounds of a stable and definite character. The paraffins or hydrocarbons of the marsh-gas series, on the other hand, do not form such compounds with bromine. This behaviour towards bromine affords different results when shale and petroleum products are operated upon, in consequence of their dissimilar constitution. The method of procedure to determine this adopted by Mr. ALLEN is as follows:—

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* ALLEN, "Year Book of Pharmacy," 1881, 490.

A solution of sodium hypobromite is prepared by measuring out 40 c.c. of bromine, gradually adding solution of caustic soda (avoiding any rise of temperature) till the liquid is slightly alkaline and of a light-yellow colour, and then diluting the liquid with water to 1 litre. The strength of this solution is then ascertained by measuring out 20 c.c., diluting with about 150 c.c. of water in a porcelain dish, adding a strong solution of pure potassium iodide, and acidulating with hydrochloric acid. If any black precipitate of iodine occur, more potassium iodide solution is added till the mixture has a clear brown colour. The iodine set free is then titrated with deci-normal solution of sodium hyposulphite (24·8 gms. of crystallized $Na_2S_2O_3$ per litre), each c.c. of which, if of accurate strength, corresponds to ·008 gm. of bromine in the 20 c.c. employed. The end of the reaction is indicated by the disappearance of the brown colour, and may be rendered still more sharp by adding a few drops of starch solution towards the end of the titration.

Five grams or 5 c.c. of the sample are next placed in a small glass-tapped separator, or burette, 5 c.c. of the bromine solution added, the whole acidulated with hydrochloric acid (dil.), and well agitated. The liberated bromine will be dissolved by the hydrocarbons, in most cases forming a bromide, or bromo-substitution product. In either case the red colour of the free bromine will disappear partially or completely. If, on standing a minute or two, the layer of hydrocarbon is found to have a marked red or yellow colour, the bromine treatment is at an end, but, otherwise, a further addition of a known measure of hypobromite solution is made, and again agitated. Excess of bromine solution having been added, as indicated by the permanent red or yellow colour of the hydrocarbon layer, the mixture is allowed to rest for a few minutes to permit the aqueous liquid to separate. In most cases this occurs readily, but in others the brominated oil adheres to the sides of the vessel, and, if about the same density as the aqueous liquid, only separates with great difficulty. In such cases it is desirable to add sufficient petroleum spirit to cause the hydrocarbon to rise readily to the surface. This plan never fails. The petroleum spirit employed may be ordinary commercial "benzoline," previously agitated with enough bromine water to render it permanently coloured, and then with sufficient soda to decolorize it. Treated in this manner, it is rendered indifferent to bromine.

Complete separation of the two layers having been effected, the aqueous liquid is run off through the tap into a porcelain basin, and then brominated oil is shaken with sufficient solution of caustic soda to render it colourless. The soda solution is run off into the porcelain basin, the oil washed by agitation with a little water, and the washings also run off. Potassium iodide is then added to the liquid in the basin, and the mixture is rendered distinctly acid by hydrochloric acid. The whole is then titrated with hyposulphite in the same manner as the bromine solution. The quantity of bromine thus found is the excess employed, and, if deducted from the total quantity present in the hypobromite added to the oil, the weight of bromine will be found which is required to combine with the quantity of the oil taken for the experiment.

When a solid hydrocarbon, such as vaseline or paraffin wax, is to be examined, 2 gms. of it are dissolved in the smallest possible quantity of petroleum spirit (previously brominated as already described) and the solution so obtained treated in the usual manner.

The following table shows the proportion of bromine which Mr. Allen found to react with samples of representative commercial samples, consisting wholly or chiefly of hydrocarbons:—

Substance.	Sp. gr. at 15·5° C.		Grams Bromine combining with 100 gms. Sample.		Percentage of Bromine in Product.	
	Shale.	Petroleum.	Shale.	Petroleum.	Shale.	Petroleum.
Naphthas:						
Gasolene...	·665	·652	67·1	5·1	41·6	4·8
Naphtha...	·718	·690	94·9	10·0	48·7	8·8
Burning oils	·801	·800	38 7	17·2	27·9	14·7
Lubricating oils.........	·889	·862 (valvoline)	56 4	21·6 (valvoline)	36·0	17·7 (valvoline)
Ditto	·875 (bloomless)	·905 (oleonaphtha)	45·3 (bloomless)	31·8 (oleonaphtha)	31·2 (bloomless)	24·1 (oleonaphtha)
Vaseline ...	...	...	...	19·7	...	16·5

From these results it will be seen that there is in each case a striking difference between the proportion of bromine assimilated by any of the shale products and the quantity which combines with the parallel product from petroleum. Thus, while the shale naphtha took up nearly its own weight of bromine, the petroleum product combined with only 10 per cent., and the gasolenes, burning oils, and lubricating oils exhibit similar but less striking differences.

Testing Ozokerit.—Dr. B. Lach[*] determines the value of ozokerit in the following manner:—100 gms. of the wax are treated at 170°–180° C. with 20 gms. fuming sulphuric acid in a weighed dish, the mixture being constantly stirred until sulphurous acid ceases to be given off. The difference in weight gives the loss due to volatilization (petroleum and water). The residue is mixed with 10 per

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[*] "Chem. Zeit." 51, 905; "Analyst," 1885, 153.

cent. of a decolorizing powder (the residues of blood-lye salt) previously dried at 140° C., and allowed to cool. One-tenth part of the mixture is then weighed out and extracted with benzol. The residue is dried at about 180° C.; the difference in weight gives the amount of wax. The operation takes about four hours, but does not require much attention.

II. LUBRICATING QUALITIES.

Lubricating Values of Oils.—The following characteristics of an efficient lubricator are given in Spon's "Encyclopædia":—

(1) Sufficient "body" to keep the surfaces, between which it is interposed, from coming into contact.

(2) The greatest fluidity consistent with (1).

(3) A minimum co-efficient of friction.

(4) A maximum capacity for receiving and distributing heat.

(5) Freedom from tendency to "gum," or oxidize.

(6) Absence of acid and other properties injurious to the materials in contact with it.

(7) High vaporization and decomposition temperature, and low solidification temperature.

(8) Special adaptation to the conditions of use.

(9) Freedom from all foreign matters.

In testing an oil to ascertain how far it meets the above requirements, the following points should be investigated:—

1°. *Identification* and *purity* } By general methods.
2°. *Specific gravity* }

3°. *Viscosity;* 4°. *Gumming.*—These can be both ascertained at once by noticing the time required by a drop to traverse a known distance. Or, a piece of blotting-paper dipped in the oil is held up to drain—symmetrical drops indicate good fluidity; a spreading tendency, viscosity. Retention of the oil on the paper for some hours at 93½° C.

(200° F.), or for some days at ordinary temperatures, will show rate of gumming. (See also p. 303.)

5°. Testing as to *decomposition, vaporization,* and *ignition temperature.* Animal and vegetable oils do not vaporize, but decompose at high temperatures.

6°. *Acidity.* (See p. 236.)

7°. *Co-efficient of friction* (*i.e.,* the proportion which resistance to sliding bears to the force which presses the surfaces together). (See p. 300.)

The suitability of a lubricant depends on the work to be done, and is not constant. In order to procure the nearest possible approach to what is required for special purposes, compounds are used which are mainly mixtures of mineral and animal or vegetable oils in proportions calculated to give the particular properties required.

The general experience gained tends to the following results:*—

1°. A mineral oil flashing below 300° F. (149° C.) is unsafe, on account of causing fire.

2°. A mineral oil evaporating more than 5 per cent. in ten hours at 140° F. (60° C.) is inadmissible, as a viscous residue is apt to be left, or the bearings are left dry.

3°. The most fluid oil that will remain in its place, fulfilling other conditions, is the best for light bearings at high speeds.

4°. The best oil is that which has greatest adhesion to metallic surfaces, and the least cohesion in its own particles. In this respect we have—

1. Fine mineral oils.
2. Sperm.
3. Neat's-foot.
4. Lard oil.

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* Spon's "Encyclopædia."

5°. Consequently, finest mineral oils are best for light bearings and high velocities.

6°. The best animal oil to give body to fine mineral oil is sperm.

7°. Lard and neat's-foot oil may replace sperm when great tenacity is required.

8°. Mineral oils alone are unsuitable for the heaviest machinery, on account of their want of body, and their high degree of inflammability.

9°. Well-purified animal oils are suitable for very heavy machinery.

10°. Olive oil is the best of the vegetable oils, as it can be purified without the use of mineral acids.

11°. The other vegetable oils, admissible but far inferior, stated in order are:—

1. Gingelly.
2. Ground-nut.
3. Colza.
4. Cotton-seed.

12°. No oil is admissible which has been purified by mineral acids.

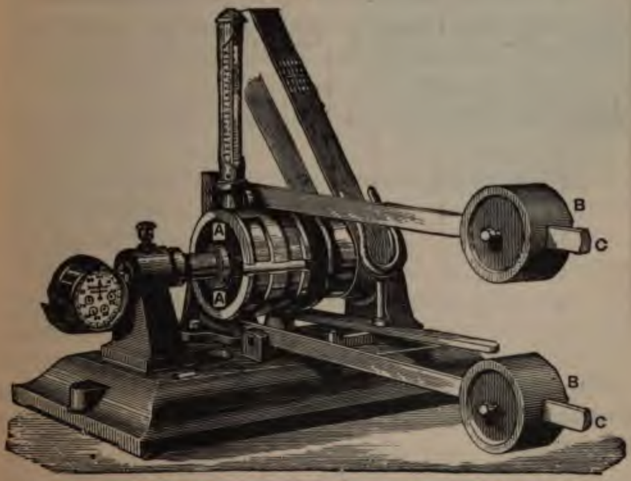
13°.

The Best Mineral Oil for	Has a sp. gr. at 60° F. (15·5° C.)	Evaporating Point.		Flashing Point.	
		Fahr.	Cent.	Fahr.	Cent.
Cylinders...........	0·893	550°	... 288°	680°	... 360°
Heavy machinery	0·880	443	... 229	578	... 269
Light bearings & high velocities	0·871	424	... 218	505	... 262

For **practically testing** the lubricating values of oils, one of the following machines (Figs. 7, 9, 10, 11) made by Messrs. W. H. Bailey & Co., of Salford, may be employed:—

1. **Stapfer's Apparatus.**—In this machine, designed by H. STAPFER, the frictional surface steps (A A) are subjected to great pressure by the weights (B B) sliding on levers (C C), and capable of being fixed at any desired distance from the drum. A small quantity of the oil (about 2 drops) is placed on the drum, or roller, and the machine is driven at 2000 revolutions per minute. That oil which permits the greatest number of revolutions to be made before the thermometer registers 200° F. is considered the best oil.

FIG. 7.

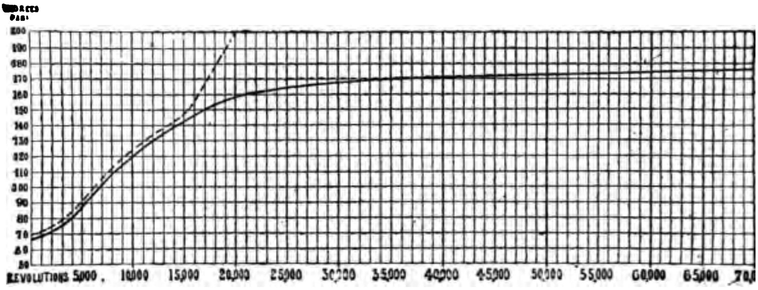


The following table may serve as a guide to those using this tester:—

	Name of Oil.	Price.	No. of Revolutions.	Degree of Temperature.		No. of Degrees raised.	No. of Revolutions to 1 degree.	Remarks.
				From	To			
1st day	No. 1 ox	5/6	13,005	80	200	120	$108\frac{45}{120}$	1st trial new oil
2nd day	Do.	5/6	11,787	78	200	122	$96\frac{75}{122}$	No fresh oil was added for the second trial
1st day	Sperm oil	9/-	16,944	65	200	135	$118\frac{114}{135}$	1st trial new oil
2nd day	Do.	9/	13,104	62	200	138	$94\frac{132}{138}$	No fresh oil was added for the second trial
1st day	Minrl. oil	3/6	11,831	65	200	135	$87\frac{86}{135}$	1st trial
2nd day	Do.		0	0	0	0	0	2nd trial, after standing 24 hours, the saddles were found to be so glued to the drum that the machine could not be started, though the belts were tightened, showing that the oil was of so gummy a nature as to be useless after once using.

The results obtained may be recorded as in the following diagram, showing the revolutions required to produce frictional heat:—

FIG. 8.



Hours and minutes may be observed instead of the exact number of revolutions, as it really amounts to the same thing if the speed is anything like equal.

Fig. 8 shows a simple design for diagram of comparative results attainable. The two lines illustrate the behaviour of two different samples of oil under test. The bottom line shows a splendid quality of prepared and purified sperm that, starting at a temperature of 67° F., has with 70,000 revolutions only attained 176°; while the other, an indifferent mixed oil, attains 200° with only 19,000 revolutions. By means of a diagram like this a permanent record of all tests can be kept for future guidance.

If the diagram is made large enough, it may be used for a dozen different tests. A good way is to use a different coloured ink for each distinct oil.

The following results were obtained by Mr. J. VEITCH WILSON, of Manchester, by the Stapfer apparatus, but operating in a different manner from that recommended above. Wishing to ascertain the effect of different oils, as nearly as possible, under conditions of actual working, Mr. WILSON used 10 or 12 drops of oil, and ran the machine for one hour and a half, noting the time taken to get up full speed, the temperature attained and maintained during each experiment, and, in the case of some oils, the point at which they began to smoke and the condition of the brasses after each trial. Each oil was tested three times—once in the morning, once in the forenoon, and once in the afternoon, and the instrument was thoroughly cleaned between each test.

The figures in last column, headed "Heat," represent the average maximum temperature maintained during three tests of an hour and a half each, of each oil examined, save in the case of the mineral oils, the trials of which had to be stopped in from thirty to sixty minutes, as the oil became by that time exhausted, and there was danger of spoiling the tester.

Name of Material.	Sp. gr. at 60° F. 1.	Body, in Seconds, at			Heat Developed. 5.
		60° F. 2.	120° F. 3.	180° F. 4.	Fahr.
Water	1000	—	—	—	—
Castor oil	960	—	132	41	158°
Resin oil	990	—	—	—	155
Engine tallow	—	Solid	41	26	—
Tallow or animal oil	—	143	37	25	141
Neat's-foot oil	—	112	40	29	—
Rape oil	916	108	41	30	148
Lard oil	916	96	38	28	146
Olive oil	915	92	37	28	143
Sperm oil	880	47	30	25	133
Mineral oil	905	45	—	—	121
"	875	30	—	—	117

The figures in the second, third, and fourth columns indicate in seconds the relative "body" of each oil at 60°, 120°, and 180° F., obtained by noting the time taken by a given quantity of oil in flowing through the orifice of Townson & Mercer's viscosity apparatus (see Fig. 13, p. 306).

Mr. Wilson points out that there is a uniform coincidence between the body or thickness of the oil, as shown in columns 2, 3, and 4, and the temperature developed by each, as shown in the last column. The only apparent discrepancy occurs in the case of tallow oil, which, although much thicker than rape, lard, or olive oil, at 60° F. develops a lower temperature than these; but if attention be directed to the respective bodies of these oils at 120° F., and more particularly at 180° F., it will be found that the anomaly disappears, and the irregularity may be explained by the fact that, as tallow oil frequently contains a good deal of stearine, a higher temperature may be required to thoroughly liquefy it than is required by the other oils.

Fig. 9.

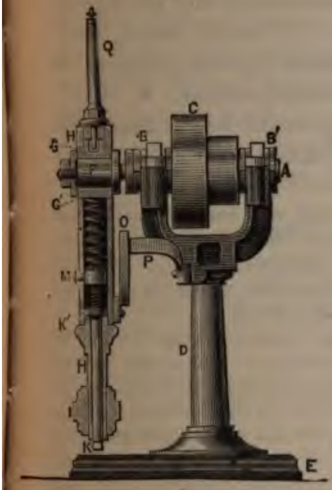
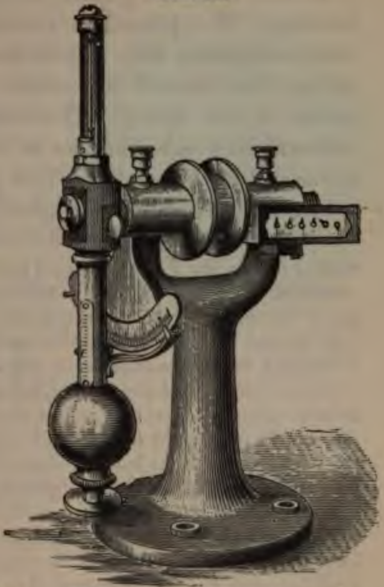


Fig. 10.



2. **Thurston's Apparatus.**—This is the invention of Prof. R. H. Thurston, of Hoboken, New Jersey.* Figs. 9

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* **Directions for using Thurston's Friction Apparatus.**—Test the lubricant at the pressure under which it is proposed that the journal on which it is to be used shall run.

The machine is fitted for a wide range of pressures, as is seen on the index-plate M N, on the pendulum H H (Fig. 9), where the large figures represent the total pressures on the journal, and those opposite, the corresponding pressures per square inch.

The speed of the machine, when the belt is upon the largest pulley of the cone C, should be that which will give the least speed of rubbing at the surface of the testing journal, which is to be usually adopted.

Co-efficient of Friction.—The figures on the arc P P, traversed by the pointer O, attached to the pendulum, are such that the quotient of the and 10 are illustrations of the machine—differing slightly in form, but identical in principle.

In each there is a journal carrying a small shaft in two bearings. The journal is grasped by brass steps which are in connection with a pendulous weight and are forced against the journal by means of a screw which compresses a coil spring. The amount of this pressure is indicated on a scale like that of a spring balance. A "bob" at the end of the pendulous arm gives the weight necessary to resist deflection. The angle of deflection is measured on

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reading on the arc P P, by the total pressure read from the front of the pendulum at M N, gives the "co-efficient of friction"—*i.e.*, the proportion of that pressure which measures the resistance due to friction.

A printed table is furnished with each machine, giving these co-efficients for a wide range of pressures and arc-readings.

To determine the Lubricating Quality.—Remove the pendulum H H from the testing journal G G, adjust the machine to run at the desired pressure by turning the screw-head K projecting from the lower end of the pendulum, until the index M above shows the right pressure; adjust it to run at the required speed by placing the belt on the right pulley C.

Throw out the bearings by means of two little cams on the head of the pendulum H in the small machine, or by setting down the brass nut immediately under the head in the large machine. Carefully slide the pendulum upon the testing-journal G G, and see that no scratching of journal or brasses takes place.

Oil the journal through the oil-cups or the oil-holes; set the machine in motion, running it a moment until the oil is well distributed over the journal.

Next stop the machine; loosen the nut or the cams which confine the spring, and, when it is fairly in contact and bearing on the lower brass with full pressure, turn the brass nut or the cams fairly out of contact, so that the spring may not be jammed by their shaking back while working. Now, start the machine again and run until the behaviour of the oil is determined, keeping up a free feed throughout the experiment.

At intervals of one or more minutes, as may prove most satisfactory, observe and record the temperature given by the thermometer Q Q, and the reading indicated on the arc P of the machine, by the pointer O. When both readings have ceased to vary, the experiment may be terminated.

Remove the pendulum, first relieving the pressure of the spring, and

an arc or quadrant in such units that the division of the figures may be read off, and give, not only the angle of deflection, but also the co-efficient of friction. A thermometer on the top brass gives the temperature in a manner similar to that of the Stapfer tester. The machine is used much in the same way as that previously described. It is employed in the engineering department of the United States Navy and by various Railway Companies. The following table gives the results of experiments conducted under the personal direction of Prof. THURSTON, the rubbing surfaces being driven at the rate of 750 feet per minute:—

Co-efficients of Friction and Endurance of Lubricants.

Name of Oil.	Pressure.	Endurance.	Rise of Temperature.	Co-efficient.	Name of Oil.	Pressure.	Endurance.	Rise of Temperature.	Co-efficient.
	lb.	Min	F.			lb.	Min	F.	
Sperm—winter ...	8	111	230	0·13	Cotton-seed........	8	107	185	0·16
	16	29	225	0·10		16	45	275	0·12
	48	9	195	0·08		48	12	310	0·07
" summer....	8	165	170	0·13	Palm..................	8	49	195	0·17
	16	33	215	0·11		16	15	235	0·13
	48	7	265	0·10		48	9	295	0·07
Lard	8	77	175	0·16	Castor	8	45	160	0·19
	16	27	250	0·12		16	35	180	0·11
	48	11	260	0·07		48	11	375	0·07
Neat's-foot	8	106	205	0·15	Cod	8	40	200	0·15
	16	31	275	0·10		16	14	175	0·12
	48	6	190	0·10		48	9	220	0·07
Olive	8	83	170	0·13	Crude Mineral ...	8	129	105	0·10
	16	41	245	0·10		16	97	285	0·10
	48	14	240	0·06		48	5	270	0·10

clean the journal and brasses with exceedingly great care from every sign of grease; and be especially careful not to leave a particle of lint on either surface, or any grease in the oil-cup or oil-passages.

A comparison of the results thus obtained with several oils will show their relative values as reducers of friction.

In each case, record in tables like the blanks sent with the machine:—

This high speed was purposely chosen, otherwise the trials under moderate pressure might occupy many days. It will be observed that, in addition to giving the time of endurance in minutes, the pressure per square inch on the journal has been noted, as well as the rise of temperature and the co-efficient of friction. It will also be seen that the various lubricants were tested with 8 lb., with 16 lb., and with 48 lb. pressure per square inch, so that the behaviour of each oil under heavy and light pressure could be criticized.

3. **Pendulum Test.**—Mr. BAILEY has designed a pendulum test which may be found useful in testing oils which will not be subjected to heavy pressures, such as those for clocks and watches, and light spindles. It consists of a pendulum (Fig. 11) to which is attached a link, which imparts a reciprocating motion to a small piece of brass. By simply placing one drop of oil on the surface of the brass and noticing how many times different oils will permit the pendulum to vibrate without stopping, useful information may be obtained about the value of a lubricant when not subjected to heavy wear and tear. The behaviour of an oil may

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1. The pressure and speed of rubbing at each trial.
2. The observed temperature.
3. The readings on the arc of the machine.
4. The calculated co-efficients of friction.

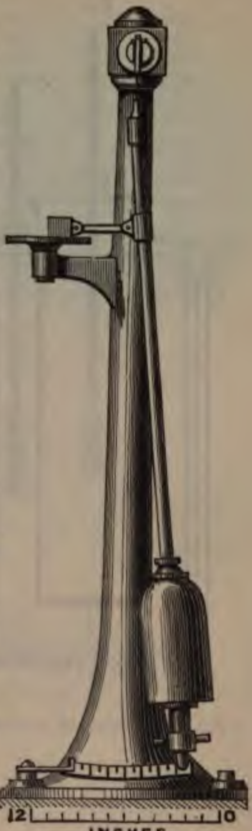
Enter at the end of the trial the average and the minimum co-efficients, and the total distance *rubbed over* by the bearing surfaces.

An Approximate Value, by which to compare the oils, can be calculated, based on the assumption that they will have a money-value proportionate to their durability and to the *inverse* ratio of the value of the co-efficient of friction. Thus: suppose two oils to run, the one ten minutes and the other five, under a pressure of 100 lb. per square inch, and both at the same speed, and suppose them to give on test for friction the co-efficients 0·10 and 0·06 respectively.

Their relative values might be taken at $\frac{10}{10} = 1$, and $\frac{5}{6} = 0·833$. If the first is worth say 100 pence, the second should be worth 83⅓ pence.

be also noticed when subject to atmospheric influences by taking note of the different vibrations, with one, two, or more days of an interval; it may thus indicate any process of deterioration and any incapacity to resist oxidation and tendency to become varnish. This mode of testing may be valuable to those who have not steam power to drive the Thurston or Stapfer testers, and, the inventor claims, it will give, in a very definite manner, the test for oxidation after exposure, quicker, probably, than those instruments.

FIG. 11.



Pendulum Friction Test.

Viscosity.—The determination of the *viscosity* of oils is of great importance in forming a judgment as to their relative value for lubricating purposes. LAMANSKY * uses the apparatus represented in Fig. 12.

The arrangement consists of two concentric cylindrical vessels of sheet brass. The inner one serves for the reception of the oil, and is provided with a metal tube having a bore 1 mm. wide. The latter can be closed by means of a sliding shutter at the bottom of the outside vessel. The oil to be tested having been introduced into the inner vessel, the outer one is filled with water, w means of a steam pipe, can be heated to the desi perature. As soon a is of the required tem the slide is drawn, and of the oil are allowe out through the narr the time occupied bein Taking the time in running out 100 water from the same tus as unity, the visc the oils can be expr the ratio existing this time and that by oil at the same t ture. This ratio LA calls "specific viscosi is desirable that the should be determine least, three different atures—say 10°, 30 50° C.—as the visc oils exhibits great dif at various temperatur

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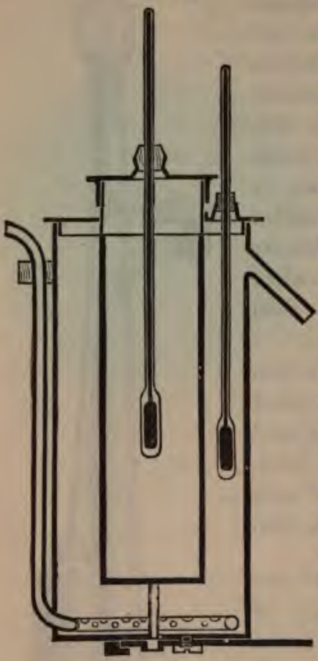
* "Dingl. Pol. Journ." 248, 29; "J. Soc. Chem. Ind." ii. 417.

FIG. 12.



The following are cific viscosities of various oils obtained by this meth

Name of Oil.	Sp. gr. at 15° C.	Spec. viscosity at 19° C.
Cylinder oil, G.	·917	191
Machine oil, 1 a, G.	·914	102
Wagon oil, G.	·914	80
„ R.	·911	70
Naphtha residues, N	·910	55
Oleo-naphtha, O, R.	·910	121
Wagon oil, O, G.	·907	60
Machine oil, 1 b, G.	·907	59
Oleo-naphtha, 1, R.	·904	66
Machine oil, 2, G.	·898	20
Oleo-naphtha, 2, R.	·894	20
Oleonide, 16, R.	·884	28
„ 12, R.	·881	24
„ best quality, R.	·881	26
Olive Oils.		
Huile vierge	·916	23
Ol. prov. opt. rect. I.	·916	22
„ „ II.	·916	22
Sperm Oils.		
Winter oil	·879	9
Summer oil	·875	8

In practice it will be found desirable for each operator to determine his own rates for the oils he examines, as the results by different apparatus are not strictly comparable.

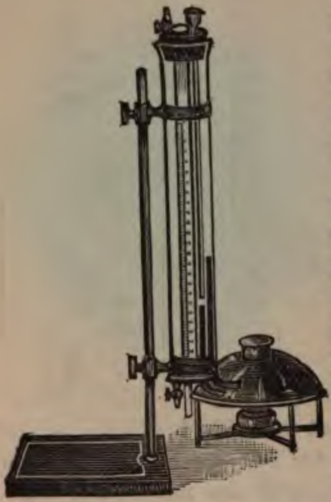
Coleman found the following figures:—

Oils Examined.	Equal Measures required the following Number of Seconds to run out at 50° C.
Olive	495
Colza (French refined)	660
Earth-nut	480
Sperm	300
Seal	390
Whale	460
Neat's-foot	510
Lard	420
Tallow	450

Another convenient viscometer is one manufactured by Messrs. TOWNSON & MERCER, and represented in Fig. 13.

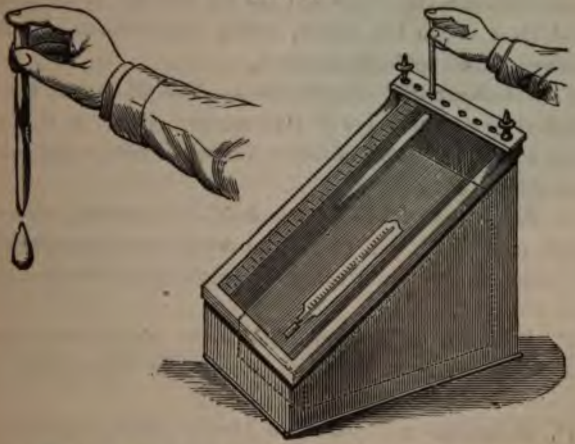
Fluidity of Oils.—It is often advantageous to compare the thinness or fluidity of oils at increased temperatures. The following arrangement, shown in Fig. 14, designed by Mr. W. H. BAILEY, affords a ready method for testing oils in this way:—

FIG. 13.



It consists of a tin box in which is fixed at an angle a piece of plate-glass 12 inches in length. A thermometer can be seen through it. A graduated scale at the side of the box enables the track of the oil to be measured. The box has a door at the back through which a copper vessel full of boiling water can be introduced. The box is lined with felt to prevent rapid radiation, and, when the door is closed, several experiments may be conducted before the apparatus becomes too cool for use. At the commencement the thermometer should indicate 200° F., and a drop of the oil being then placed upon the upper end of the glass will flow down a few inches, and thus the varying fluidity of oils subjected to increase of temperature may be compared. There are many oils, otherwise good lubricants, which become too thin when exposed to slight heat. Watchmakers' oil should be tested both by heat and cold. If, after exposure to the temperature of 200° F. as above, the oil dries to a varnish in two or three days after the test, it is considered unfit for use. The "cold" test is applied thus:—15 parts of Glauber's salt are put into a small glass vessel, and a small bottle of the sample is immersed in this. A mixture of 5 parts of hydrochloric acid and 5 parts of cold water is then added. The temperature is ascertained by a thermometer, and the behaviour of the oil noted. Instead of the freezing mixture mentioned, pounded ice, or a mixture of ice and common salt, may be employed.

Fig. 14.



The following tests for the purity of mineral lubricating oils have been proposed by P. Falke:*—

1°. *Colour.*—The oil must be perfectly clear, and as light as possible. It should not be turbid, which may be caused by the presence of water or other substances. If the turbidity is due to water, the sample froths on heating, whereas turbidity caused by solid matters, such as paraffin, disappears on warming and reappears on cooling.

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* "Chem. Zeit." 9, 906; "J. Soc. Chem. Ind." 1885.

2°. *Smell.*—This should be as little as possible, and should not increase on warming.

3°. *Behaviour with Water.*—If 3 parts of oil be shaken with 1 part of water in a test-tube, warmed, and allowed to stand in a water-bath for some time, no emulsion must appear between the water and the oil, but the latter should stand clear above the water, which should be only faintly opalescent, and perfectly neutral.

4°. *Behaviour with Caustic Soda.*—The oil should not be attacked by a caustic lye of 1·40 sp. gr., either in the cold or on warming. Saponification indicates either animal or vegetable fat.

5°. *Behaviour with Sulphuric Acid.*—On mixing with sulphuric acid of sp. gr. 1·60, it must not be coloured brown, but yellow at the most; otherwise, resins have not been carefully removed.

6°. *Behaviour with Nitric Acid.*—On mixing with nitric acid of sp. gr. 1·45, a rise of temperature takes place, but this should not exceed a certain limit.

7°. *Behaviour on Exposure to Air and Heat.*—Spread in a thin layer and exposed to the air for some time, its consistency must not change, and it should not become acid on being heated continuously above 150° C. Heated in open vessels, it should not give off combustible vapours, except at a high temperature, which is usually specified in contracts. Its flashing point should be ascertained by ABEL's apparatus.

8°. *Behaviour at a Low Temperature.*—It should bear a low temperature without losing its lubricating power, and it should not become solid even with very great cold, but should rather assume the appearance of an ointment.

9°. *Consistency.*—This determination is most important. The velocity of efflux of pure rape-seed oil is taken as a standard and that of the mineral oil compared with it.

100 c.c. of the sample are allowed to flow out of a burette with tap, and the time noted. Or, one of the several viscometers is used.

10°. *Specific Gravity.*—Oils suitable for various machinery range in sp. gr. from 0·875 to 0·950, but only a small latitude (·003 at most) is allowable in contracts.

Comparison of Russian and American Lubricating Oils.[*]

Viscosity.	Russian.			American.			Refined Rape Oil (for comparison).
	Sp. gr. ·913	Sp. gr. ·907	Sp. gr. ·898	Sp. gr. ·914	Sp. gr. ·907	Sp. gr. ·891	
At 70° F.	1400	649	173	231	171	81	321
At 120° F.	166	135	56	66	58	40	112
Loss in viscosity per cent.	88	79	67	71	66	50	65

Russian lubricating oil, besides being, as a rule, practically free from solid hydrocarbons, and therefore bearing exposure to very low temperatures without becoming solidified and clogging the bearings of machinery, has a remarkably high viscosity, in relation to its specific gravity. Notwithstanding its high viscosity Russian oil rapidly loses "body" upon being raised in temperature, and a reference to the viscosity figures for temperatures of 70° and 120° F. in the above table will show that this is the case, the loss of viscosity between the two temperatures being, in the case of the sample having a sp. gr. of ·907, 79 per cent., against 66 per cent. in the case of an American sample of the same sp. gr. Where, however, it is desirable to employ an oil of high viscosity at comparatively low temperatures, as in the lubrication of slow-running heavy machinery, the Russian product is superior to the American. Moreover, it may be urged that it is because of its high viscosity that the Russian oil is so much affected by rise of temperature, for it will be noted that in the case of the American oils, as well as in that of the Russian oils, the percentage of loss increases with the viscosity, the oils of greatest body being most affected.

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[*] Boverton Redwood, "J. Soc. Chem. Ind." 1885, 77.

III. ILLUMINATING EFFICIENCY.

In deciding upon the relative illuminating efficiency of oils it is first necessary to determine whether or not the sample is a pure specimen. For certain uses, it is also desirable to determine the behaviour of the oil when submitted to low temperatures, and to ascertain its solidifying point. It should then be tested side by side with a standard sample, as to the *duration* of the combustion of equal weights of the two oils, the lamps and wicks, of course, being of similar construction and dimensions, and all the other conditions of the experiment being also exactly parallel. Some form of the Argand lamp is the most suitable for this purpose. The wick must be trimmed and slightly charred before the commencement of the operation, the lamps and contents weighed, the lamps lighted and placed in position. The duration of the test depends upon the purpose for which the light is required, and may extend from six to sixteen hours. During the combustion, photometric observations may be taken at intervals.

There are various photometers for measuring the illuminating intensity (*e.g.*, BOUGNER'S, RUMFORD'S, WHEATSTONE'S, RITCHIE'S, BUNSEN'S, and others), but the limits of this volume do not permit a detailed description of each. The fundamental principle on which all depend is the law that the amount of light which falls on any given surface placed opposite to the light is inversely as the square of the distance of the surface from the light. The standard of comparison, and, at present, the only legal standard in England, is a sperm candle, of six to the pound, which burns ordinarily at the rate of 120 grs. per hour. This amount of light is the "unit" of illumination. Owing to fluctuations, however, in the rate of burning, no reliable determinations can be made without weighing the candles before and after each experiment. Instead of using candles themselves as a standard, the Keate's Moderator lamp,* burning sperm oil, may be used. This is suspended at the end of the photometer bar by means of a collar with lateral steel plates which rest on the knife-edges of the forked extremity of the balance. It is provided with a Methven screen, having a slit of such a size as to allow a portion of the whole light of the lamp equal to that of 2 candles to pass through it. When the wick is turned up so as to give a flame of 2 inches in height, the lamp burns at the rate of 925 grs. of sperm per hour. Or, the gas Referees' burner, consuming 5 cubic feet of gas per hour, provided with the Methven slit, allowing a light equal to that of 2 candles to pass through, may be employed, and, when gas is available, this is the most convenient method, as it does away with the necessity, so far as the standard is concerned, of weighing.

Rumford's photometer consists of a screen of white paper, before which is placed, on a table in a dark chamber, a black cylindrical rod. In operating, the two lights to be compared are so placed that two shadows are thrown upon the screen side by side, with an interval between them about equal in breadth to either shadow. The weaker light is then brought nearer to the screen till the intensity of each shadow is equal. The respective distances of the lights from the screen are next measured, or read off from fixed scales, on the table. The illuminating powers will be in direct ratio of the squares of the distances. Thus, suppose the standard candle or lamp to be 2 feet from the screen, and the light under examination at the distance of 8 feet from the same, then $\frac{8\times8}{2\times2}=\frac{64}{4}=16$; *i.e.*, the light afforded by the sample is equal in intensity to that afforded by 16 candles. If 2 candles have been used, or a lamp having the light equal to 2 candles, the result must be doubled. Sir William Thompson says the "shadow" method of Rumford will give, with care, results within 2 or 3 per cent. of accuracy.

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* Made by Messrs. Sugg & Co., Westminster.

Bunsen's photometer, or some modification of it (Letheby's or Evans') is the one generally employed in this country for testing illuminants. In it there is a sheet of thin paper, with a circle, or preferably a star, in the centre, rendered translucent by being impregnated with a mixture of benzol and spermaceti. The light to be tested is placed on one side the disc, and the standard light on the other side. The first is generally kept stationary, while the latter can be moved towards or from the disc till both sides are equally illuminated. A graduated scale then shows at a glance the number of standard candles to which the light is equal, or the distances may be measured and the calculation made as already described.

When the lamps are finally weighed, an examination is made as to the degree of charring which the wicks have sustained. An average is struck of the photometric observations taken during the testing of the duration of combustion. Those oils are to be preferred which, *cæteris paribus*, show the least falling off in light intensity towards the end of the trial.

The following calculation has to be made when the standard candles used do not burn at the normal rate of 120 grs. per hour. Suppose, for example, in burning ten minutes the candle has lost 21 grs. instead of the normal 20 grs., and that the average light during the ten minutes, read off from the scale or calculated, is 6 candles. Then, as 20 : 21 :: 6 : 6·3 standard candles burning at the normal rate.

The value of an oil expressed in terms of the "unit" of illumination may be found as follows:—Suppose that in burning for one hour an oil lost in weight 54 grs., and gave during that time a light equal to a sperm candle burning at the rate of 120 grs. per hour, then

$$\frac{120 \times 70{,}000 \text{ (grs. in gallon)*}}{54 \times \;\; 7{,}000 \text{ (grs. in lb.)}} = 22{\cdot}2 \text{ lb.,}$$

i.e., 1 gallon of the oil is equal to 22·2 lb. standard candles.

The following table by Dr. FRANKLAND shows the illuminating equivalents of different light-givers:—

	Quantities producing an Equal Amount of Light.
Paraffin oil	1 gallon
Rock oil	1·25 ,,
Paraffin candles	18·6 lb.
Sperm ,,	22·9 ,,
Wax ,,	26·4 ,,
Stearin ,,	27·6 ,,
Composite ,,	29·5 ,,
Tallow ,,	36·0 ,,

Cost of Light equal to 20 standard sperm candles burning for ten hours at the rate of 120 grs. per hour (FRANKLAND):—

	s.	*d.*		*s.*	*d.*
Wax	7	2½	Benzene	0	4½
Sperm	6	8	Coal gas	0	4¼
Tallow	2	8	Cannel gas	0	3
Sperm oil	1	10	Petroleum or Rock oil	0	3

Cost of Petroleum as an Illuminant.—Experiments

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* If the sp. gr. of the oil were (say) 0·870, then the gallon would weigh 70,000 × ·87 = 60,900 grs., instead of as above.

have been made by Messrs. B. and T. H. Redwood* as to the comparative cost of a given amount of light from petroleum oil, colza oil, and coal gas. The following table shows the mean results for the amount of light which would be obtained by burning a standard sperm candle for 1000 hours:—

Cost of 1000 "*Candle-hours.*"

From Petroleum Oil.				From Colza Oil.			From Coal Gas.		
Price per gallon.				*Price per gallon.*			*Price per* 1000 *cubic ft.*		
d. 9	*s. d.* 1 0	*s. d.* 1 3	*s. d.* 1 6	*s. d.* 3 0	*s. d.* 3 6	*s. d.* 4 0	*s. d.* 3 0	*s. d.* 3 6	*s. d.* 4 0
d. 7½	*d.* 9½	*d.* 11½	*s. d.* 1 3	*s. d.* 2 4	*s. d.* 2 8	*s. d.* 3 0½	*s. d.* 1 3	*s. d.* 1 5½	*s. d.* 1 8

These numbers show that, taking petroleum oil at 1*s.* per gallon, and colza oil at 3*s.* 6*d.* per gallon, the cost of a given amount of light is more than three times greater for the latter than for the former; and that, taking petroleum at 1*s.* per gallon, and coal gas at 3*s.* 6*d.* per 1000 cubic feet, a given amount of light from the former costs only about half what it does when obtained from the latter, while there is the additional advantage that properly purified petroleum oil in burning does not produce sulphur-compounds.†

The "Carcel," a mechanical lamp invented in 1800, by Carcel, of Paris, is the legal standard in France. The oil is forced into the wick at the foot of the reservoir by means of a pump moved by clockwork. It requires winding up

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* "Chemist and Druggist," Dec. 15, 1879.

† The Trinity House Committee have recently reported on the relative cost and efficiency of electricity, gas, and oil as illuminants, and conclude that, "for all practical purposes, gas and oil are equal," and that, "for the ordinary necessities of lighthouse illumination, mineral oil is the most suitable and economical illuminant."—"Nature," 1886, 273.

once in twelve or fifteen hours, and in burning seven or eight hours the action is said to be sufficiently uniform to maintain a light of equal intensity for that time. It should burn at the rate of 42 gms. (or 648·14 grs.) of colza oil per hour, and, under these circumstances, the French authorities claim that the light is equal to that of ten English sperm candles, but, according to the experiments of Mr. DIBDIN, the average light so obtained is only equal to 9·5 average sperm candles. Formerly, RUMFORD's shadow test was used with this lamp, but this has now been superseded by the BUNSEN disc.*

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* **Standards of Light.**—The Committee appointed to examine the standards of white light report that the present standard candle, owing to the fact that the spermaceti is not a definite chemical substance, and that the constitution of the wick is not sufficiently well defined, is not, in any sense of the word, a standard; that the French "Carcel" is also liable to variations; and that the difficulty of applying the molten platinum standard, proposed by VIOLLE, is so great as to render its general adoption almost impossible. The majority of the Committee feel satisfied that, for all present commercial requirements, the *Pentane* (C_5H_{12}) standard of Mr. VERNON HARCOURT—since it has no wick, and consumes a material of definite chemical composition—when properly defined, is an accurate and convenient standard, and gives more correctly than the so-called standard candle an illumination equal to that which was legally intended. They, however, consider that further investigation is necessary before any standard can be recommended for universal adoption.—"Nature," 1886, 236.

CHAPTER X.

RESINS AND VARNISHES.

A VARNISH—*Syn.* VERNIS (Fr.), FIRNISS (Ger.)—is any liquid matter which, when applied to the surface of a solid body, becomes dry and forms a hard, glossy coating, impervious to air and moisture. Varnishes generally consist of some resinous substance dissolved in a volatile liquid, which on evaporation leaves the resin in the form of a film. They are commonly divided into two classes—(a) *oil varnishes*, (b) *spirit varnishes*—according to the substance employed as the vehicle or solvent. For oil varnishes the solvents are fixed or volatile oils, or mixtures of them. The fixed oil used is generally pale linseed, but poppy and nut oils are also employed. The volatile oil is generally oil of turpentine, which should be pure and colourless. Turpentine varnishes dry more readily than fixed oil varnishes, are of a lighter colour, more flexible, and cheaper. They are, however, more liable to crack, and are less durable. The drying of spirit varnishes is due to the evaporation of the spirit, but the drying of oil varnishes is due to oxidation.

For spirit varnishes the solvents are spirits of wine, of not less strength than 67 o.p. (sp. gr. ·8156), and naphtha or methylated spirits for the cheaper kinds. A little camphor is sometimes dissolved in the alcohol to increase the solvent power. Spirit varnishes are the most rapid in drying, but are still more apt to crack and peel off than turpentine varnishes.

The principal substances which are dissolved in the above menstrua are the following :—

1°. *For body and lustre.*

Amber
Animé
Copal
Elemi
Lac
Mastic
Sandarac

2°. *For odour.*

Benzoin

3°. *For tinctorial effect.*

Annotta
Gamboge
Saffron
Socotrine aloes
Turmeric
Dragon's blood
Red sandal wood
Cochineal
Indigo

4°. *For black colour and body.*

Asphaltum

5°. *For toughness and elasticity.*

Caoutchouc

Resins, which are so largely used in the preparation of varnishes, are compounds of vegetable origin, exuding spontaneously from plants, or from incisions in the trunk or branches, and hardening on exposure to the air. From observations on the resinification of essential oils, DRAGENDORFF * expresses himself in favour of the theory that all resins are formed by the oxidation of hydrocarbons.

Resins containing gum or mucilage are called *gum resins;* those containing volatile oils are called *balsams.*

The resins cannot be very accurately defined, but in a general way they may be described as substances which are solid at ordinary temperatures, more or less transparent, inflammable, readily fusible, do not volatilize unchanged, become negatively electrified by rubbing; are insoluble in water, but soluble in alcohol; mostly inodorous, and readily incorporated with fatty bodies by fusion. Their specific gravity varies from 0·9 to 1·2. The following is a brief description of the resins and other substances chiefly used in varnish-making:—

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* "Archiv der Pharm." [3] xv. 50.

Amber.—*Syn.* ELECTRON, Gr.; ELECTRUM SUCCINUM (Ph. D.), L.; AMBRE, SUCCIN, Fr.; BERNSTEIN, Ger.; LYNX-STONE, LAPIS LYNCIS.—A well-known, yellowish, semi-transparent, fossil resin, of which trinkets and the mouth-pieces of pipes are commonly made.

It is found in detached pieces on the sea-coast, and is dug up in diluvial soils. The amber of commerce comes chiefly from the southern coasts of the Baltic, where it is cast ashore between Königsberg and Memel, and from Germany, Poland, Sicily, and Maryland (U.S.), where it is dug out of beds or mines. It has also been found on the shores of Norfolk, and small pieces are occasionally dug up in the gravel pits around London. It is probably an antediluvian resin, and when found on the coast is supposed to have been separated, by the action of the sea, from neighbouring beds of lignite. Much diversity of opinion formerly prevailed amongst naturalists and chemists as to the origin of amber, but its vegetable origin is now generally admitted. According to Sir DAVID BREWSTER,* its optical properties are those of an indurated vegetable juice. Insects and vegetable fragments are frequently found imbedded in it, and this in a manner which could only have occurred when the resin was a viscid fluid. Microscopical researches have led to the conclusion that it is the production of some species of pine, closely allied to *Pinus balsamea*.†

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* "Edin. Phil. Journ." ii.

† "Entom. Transac." i. and ii.

Prop. Hard; brittle; tasteless; glossy; generally translucent, but sometimes opaque, and occasionally, though rarely, transparent; colour generally yellow or orange, but sometimes yellowish-white; becomes negatively electric by friction; smells agreeably when rubbed or heated; fracture conchoidal and vitreous or resinous; soluble in alkalies and, without decomposition, in oil of vitriol, which then becomes purple; insoluble in the essential or fixed oils without long digestion and heat; soluble in chloroform; melts at about 550° F.; burns with a yellow flame, emitting at the same a peculiar fragrant odour, and leaving a light and shiny coal. By dry distillation it yields inflamm[illegible], gases, a small quantity of water, a little acetic acid, a volatile oil (oil of amber, OLEUM SUCCINI), at first pale, afterwards brown, thick, and empyreumatic and succinic acid (ACIDUM SUCCINICUM) with 12 to 13 per cent. of residual charcoal. Sp. gr. 1·065 to 1·09, but usually about 1·07 (1·074 to 1·094, HAGER). It cannot be fused without undergoing more or less chemical change.

Amber may be known from mellite and copal, both of which are occasionally substituted for it, by the following characteristics:—1. Mellite is infusible by heat, and burns white. 2. A piece of copal, heated on the point of a knife, catches fire, and runs into drops, which flatten as they fall. 3. Amber burns with spitting and frothing, and when its liquefied particles drop they rebound from the plane on which they fall (M. HAÜY). 4. Neither mellite nor copal yields succinic acid by distillation, nor the agreeable odour of amber when burnt; nor do they become so readily electric by friction. 5. The "bromine absorption" of amber is much lower than that of copal.

The chief use of amber is to be made into the mouthpieces for pipes, beads for necklaces, and other ornaments and trinkets. It also forms the basis of several varnishes.

In medicine, it was formerly given in chronic coughs, hysteria, &c.

The finer sorts of amber fetch very high prices. A piece 1 lb. in weight is said to be worth from £10 to £15. 5000 dollars are said to have been offered, some years since, in Prussia, for a piece weighing 13 lb. It is more valued in the East than in England, chiefly, perhaps, on account of the Turks and other Orientals believing it to be incapable of transmitting infection. In the royal cabinet, Berlin, there is a piece weighing 18 lb., supposed to be the largest ever found. The coarser kinds alone are employed in medicine, varnishes, &c.

Amber may be coloured by heating in linseed oil to about 150° or 200° C. Dragon's-blood, alizarin, purpurin, and indigo will all dissolve in this oil, and are not decomposed at the temperatures mentioned. Fuchsine, aniline violet, methyl green, and alkali blue will not dissolve in linseed oil. The oil and colouring matter are mixed in weighed quantities, the amber hung in the mixture, and the whole heated to 190°–200°, kept at that temperature for a few minutes, and then allowed to cool slowly to the temperature of the air. By varying the amounts of colour used, different tints are produced; *e.g.*, indigo gives a lighter or darker green, dark blue, or black, according to the quantity used. To obtain pure colours, the bath should be changed from time to time, except for black, when it is not so necessary.*

Natural amber is adulterated to a large extent with colophony,† and insects, moss, &c., such as occur in genuine amber, are introduced into the substitute in order to heighten the deception. The artificial product is, however, easily known by the fact that it melts at a much lower temperature than true amber. Pieces also of genuine amber, after softening the edges with caustic potash solution, can be joined together very easily, while fragments of the fictitious article, similarly treated, will only re-unite with great difficulty.

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* Hanausek, "Chemisches Centralblatt," 15, 461; "J. Soc. Chem. Ind." 1884, 491.

† "Chem. Zeitung," 56, 1035; "Oil and Paint Rev." 1, 6; "J. Soc. Chem. Ind." 1882, 459.

Animé.—*Syn.* GUM-ANIMÉ, A. RESIN, ANIMÉ (Fr.), ANIME-HARZ, KOURBARILL-HARZ (Ger.), COURBARIL JUTAIBA (Nat.). —A pale, brownish-yellow, transparent, brittle resin, which exudes from the *Hymenæa courbaril* (Linn.), or locust-tree, the *H. martiana*, and other species of *Hymenæa* growing in tropical America. It contains about 0·2 per cent. of volatile oil, which gives it an agreeable odour; melts without decomposition; is (nearly) insoluble in alcohol and in caoutchoucine, but forms a gelatinous mass in a mixture of the two (URE). It burns readily, emitting a very fragrant smell. Sp. gr. 1·054 to 1·057.

It is used as a fumigation in spasmodic asthma; in solution, as an embrocation; and in powder, as a substitute for gum guaiacum. In this country, however, its chief use is in varnishes.

Benzoin.—*Syn.* GUM BENZOIN, BENJAMIN, GUM BENJAMIN, BENZOINUM (Lat.), BENJOIN (Fr.), BENZÖL (Ger.).—The balsamic resin exuded from incisions made in the stem of the *Styrax benzoin*, a native of Sumatra, Java, Borneo, Laos, and Siam.

Odour, agreeable, somewhat like that of vanilla, but more balsamic; fracture, conchoidal; appearance, greasy; sp. gr. 1·063 to 1·092. According to HAGER, the sp. gr. of Siam benzoin is 1·235; Penang benzoin, 1·145 to 1·155; and of Borneo benzoin, from 1·165 to 1·170. It fuses at a gentle heat, and exhales white fumes, which, on condensation, are found to be benzoic acid contaminated with a little volatile oil. Alcohol dissolves the larger portion of it, ether much less, and the volatile and fixed oils only a little. It contains from 9 to 18 or 20 per cent. of benzoic acid, according to quality. It burns with an agreeable odour. The resin and its alcoholic solution strike a bright-red colour with oil of vitriol, and a green colour with perchloride of iron.

It is chiefly employed in perfumery, and as an ingredient in incense, fumigating pastilles, &c.; also in court-plaster, in certain cosmetics, and to scent the varnish used for snuff-boxes, walking-sticks, &c.

Colophony.—*Syn.* Rosin.—This is the residue remaining in the retort after the distillation of common turpentine. When it retains some water, it is known as white and yellow resin, and is in this state translucent. When deprived of water by fusion, it is called brown or black resin, colophony, rosin, or fiddler's rosin.

Rosin is a brittle, tasteless, and almost inodorous substance, of a smooth shining fracture. Sp. gr. about 1·080. Hager finds the sp. gr. of pine resin 1·083–1·084, and of very dark colophony 1·100. It softens at 160° F. Fuses at 275° F.

Resin, or Rosin, Oil.—This is a product of the dry distillation of resin. The apparatus for its production consists of an iron pot, a head-piece, a condensing arrangement and a receiver.

In distilling the resin, a bright oil first comes over with water. As soon as a cessation in the flow of the distillate occurs, the receiver is changed, and the heat is further raised, when a red-coloured and heavy rosin oil comes over. The black residue remaining in the pot is used as pitch. The light oil, called "pinoline," is rectified, and the acetic acid water, which passed over with it, is saturated with calcium hydrate, filtered, and evaporated to dryness, and the calcium acetate obtained is employed in the manufacture of acetic acid. The rosin oil, obtained after the light oil has passed over, has a dark violet-blue colour, and is called "blue rosin oil." The red oil is boiled for a day with water, the evaporated water being returned to the vessel; next day the water is drawn off, and the remaining rosin oil is saponified with caustic soda lye of 36° Baumé, and the resulting solid mass is distilled so long as oil passes over.

The product obtained is "rectified rosin oil," which is allowed to stand in iron vessels protected by a thin layer of gypsum, whereby, after a few weeks, a perfectly clear oil is obtained free from water. The oil of first quality is procured by a repetition of the foregoing process upon the once rectified oil. The residues of both operations are melted up with the pitch.*

Rosin oil is employed in the manufacture of axle grease, the oil being previously converted into a soap by heating with slaked lime.

Rosin oil gives a characteristic violet colour with anhydrous stannic chloride. If it is mixed with fatty oils, Mr. A. H. ALLEN has pointed out that the test may still be successfully applied by distilling the mixture and applying the test to the first fractions which pass over. Nitric acid is also said to be a good test for rosin oil when mixed with fat oils, as the colour thereby developed is much greater than in pure oils. Sometimes it may be detected by the smell. The presence of 10 per cent. of rosin oil in non-drying oils delays their solidification with the *elaïdin* test. For methods of detecting its admixture with mineral oils, see p. 281.

Copal.—*Syn.* GUM COPAL.—This resin exudes spontaneously from various trees belonging to the genera *Hymenæa*, *Guibourtia*, and *Trachylobium*. The varieties commonly met with in commerce are East Indian copal, or animé (produce of *Hymenæa courbaril*), and West Indian copal, obtained from numerous species.

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* "Dingl. Polytech. Journ." ccvi. 246; "Jour. Chem. Soc." New Series, vol. xi. 304.

When of good quality, it is too hard to be scratched by the nail, has a conchoidal fracture, and a specific gravity ranging from 1·050 to 1·080. Unlike others, the copal resins are soluble with difficulty in alcohol and essential oils, and this property, combined with their extreme hardness, renders them very valuable for making varnishes.

Dammar.—*Syn.* GUM DAMMAR, DAMMARA, DAMMAR-PUTI (*i.e.*, CAT'S-EYE RESIN, on account of its lustre).—This is obtained from the *Pinus dammara*, or *Dammara alba*, a coniferous tree, indigenous in the East Indies and the Moluccas, and also from the *Dammara australis*, which grows in New Zealand. The product of the former is known as East Indian dammar, and the latter as Australian dammar. The East Indian dammar is that ordinarily met with in commerce.

As it exudes from the tree, it occurs in somewhat transparent lumps, varying in size from that of a pea to that of a hen's egg. Sp. gr. 1·04 to 1·09; odour, resinous; fracture, conchoidal; ash, about 0·2 per cent. The resin is separable into—

1°. α-resin, or hydrated dammarylic acid: about one-third of the whole, soluble in weak alcohol;

2°. β-resin, or anhydrous dammarylic acid: soluble, after removal of *α-resin*, in absolute alcohol;

3°. Dammaryl, extracted by ether from the residue after separation of 1° and 2°.

Elemi.—*Syn.* GUM ELEMI.—"A terebinthinate concretion from an uncertain plant" (Ph. L.). Mexican elemi is known to be the produce of a species of the genus *Elaphrium*. Manilla elemi is probably the product of *Canarium commune*.

The elemi of commerce is of a pale-yellow colour, brittle superficially, but soft and tough within. It has a warm bitter taste and a fragrant aromatic smell, resembling fennel and juniper. It is only partially transparent even in thin plates, is very fusible, and has density a little greater than that of water. It contains about 12½ per cent. of volatile oil (oil of elemi). It is used to give toughness to lacquers and varnishes. It is often adulterated, or a factitious preparation is sold for the genuine gum. The fraud may be detected by exposing the suspected article to heat, along with a little water, when the factitious fragrance of the spurious article evaporates, and the coarse terebinthinate smell of the resin used becomes readily distinguishable.

Lac.—*Syn.* LACCA, L.—This resin, combined with much colouring matter, is produced by the puncture of the female of a small insect called the *Coccus lacca*, or *ficus*, upon the young branches of several tropical trees, especially *Ficus indica*, *Ficus religiosa*, and *Croton lacciferum*. The crude exudation constitutes the *stick-lac* of commerce. *Shell-lac* or *shellac* is prepared by spreading the resin into thin plates after being melted and strained. *Seed-lac* is the residue obtained after dissolving out most of the colouring matter contained in the resin.

Shellac is the kind most commonly employed. The palest is the best, and is known as "orange-lac." The darker varieties—"liver-coloured," "ruby," "garnet," &c.—respectively diminish in value in proportion to the depth of their colour. Lac was formerly much used in medicine; its action, if any, is probably that of a very mild diuretic. It is now chiefly used in dentifrices, varnishes, lacquers, and sealing-wax.

Lac, Bleached.—*Syn.* WHITE LAC, LACCA ALBA.—Prepared by dissolving lac in a boiling lye of pearl-ash or caustic potash, filtering, and passing chlorine through the solution until all the lac is precipitated. This is then collected, well-washed, and pulled in hot water, and, finally, twisted into sticks and thrown into cold water to harden.

It is used to make pale varnishes and the more delicately coloured sealing-wax. Specific gravities (HAGER)—light shellac, 1·113–1·114; dark, 1·23; bleached, 0·965–0·968.

Mastic.—*Syn.* MASTICH, GUM MASTIC, MASTICHE, L.—The "resin flowing from the incised bark of *Pistacia lentiscus, var. Chia*" (Ph. L.). It occurs in pale-yellowish, transparent, rounded tears, which soften between the teeth when chewed, and giving out a bitter, aromatic taste. Sp. gr. 1·07 (1·056 to 1·060, HAGER). It is soluble both in rectified spirit and oil of turpentine.

Sandarach.—*Syn.* SANDRAC.—A resin obtained from *Thuja articulata* and *Juniperus communis* (in warm climates). It is slightly fragrant, and freely soluble in rectified spirit. Its specific gravity is from 1·05 to 1·09 (HAGER'S determinations are from 1·038 to 1·044). It is used as incense, pounce, in varnishes, &c.

Annotta.—*Syn.* ANOTTO, ANNATTO, ANNATTA, ARNATTO, ARNOTTO; ORLEANA, TERRA ORLEANA; RONCOL, ROCON, RONCON (Fr.); ORLEANS (Ger.).—A colouring matter forming the outer pellicle of the seeds of the *Bixa orellana* (Linn.), an exogenous evergreen tree, common in Cayenne and some other parts of tropical America, and extensively cultivated in the East and West Indies. It is usually obtained by macerating the crushed seeds, or seed-pods, in water for several weeks, ultimately allowing the pulp to subside, which is then boiled in coppers to a stiff paste, and dried in the shade. Sometimes a little oil is added in making it up into cakes or lumps.

Good annotta is of a brilliant red colour, brighter in the middle than on the outside, soft and smooth to the touch; has a characteristic, but not a putrid, smell. It is scarcely soluble in water; freely soluble in alcohol, ether, oils, and fats, to each of which it imparts a beautiful orange colour, and in alkaline solutions, which darken it. Strong sulphuric acid turns it blue.

Annotta is very frequently adulterated. The adulterants which have been used are meal, flour, or farina, chalk, gypsum, pearl-ash; oil, or soap, to give it an unctuous character; turmeric, Venetian red, red ochre, orange chrome, and red lead, to give it colour; common salt and sulphate of copper, to prevent decomposition. Sometimes a little carbonate of ammonia is added to improve the colour. When pure, it contains about 28 per cent. of resinous colouring matter and 20 per cent. of colouring extractive matter (Dr. JOHN), and should leave only a small quantity of insoluble residuum after digestion in alcohol, while the ash resulting from its incineration should not exceed 1·5 to 2 per cent. The quantity, colour, &c., of the ash will give a clue to the inorganic adulterants, if any are present, which may then be followed up by a chemical examination. A correct determination of ash and resin is all that is required to definitely pronounce upon the purity or impurity of a sample.

The following is an analysis by Mr. A. W. BLYTH of a fair commercial sample. The sample was in the form of a paste; colour, deep red; odour, peculiar but not disagreeable.

Water	24·2
Resinous colouring matter	28·8
Ash	22·5
Starch and extractive matter	24·5
	100·0

The following is BLYTH's analysis of an adulterated specimen. The sample was in a hard cake of a brown colour, with the maker's name stamped upon it, and marked "patent;" texture, hard and leathery; odour, disagreeable.

Water	13·4
Resin	11·0
Ash, consisting of iron, chalk, salt, alumina, silica	48·3
Extractive matter	27·3
	100·0

Thus in the one the resin was 28 per cent. and the ash 22 per cent.; in the other the resin was only 11 per cent. and the ash 48 per cent.

It is used to colour varnishes and lacquers.

Dragon's-blood.—*Syn.* SANGUIS DRACONIS, L.—A rich red-coloured resin, obtained from various species of the genus *Calamus*. Its colour, in the lump, is a dark brownish-red; in powder, bright red. It is friable, breaks with a shining fracture, and has a sp. gr. not higher than 1·196 or 1·197. When pure, it readily dissolves in alcohol, ether, and oils, yielding rich red, transparent solutions. Adulterated and factitious dragon's-blood is only partly soluble in the above menstrua, and lacks the rich colour of the genuine article. It is chiefly used to tinge varnishes and lacquers.

Gamboge.—*Syn.* CAMBOGE, CAMBOGIA (L.), GAMBOGIA (L.), GOMME-GUTTE.—"A gum-resin obtained from *Garcinia morella*" (B.P.). Also from *Stalagmites cambogioïdes*, a tree belonging to N. O. *Guttiferæ*, and growing in the peninsula of Cambogia, in Siam. The juice, which is of a yellow colour, is obtained from the bruised leaves and branches, and, having been received into cocoa-nut shells or earthen vessels, it is allowed to thicken and is afterwards made into rolls; this is "pipe-gamboge" of Siam. A portion is also formed into cakes. Cake-gamboge is a manufactured article, not entirely natural.

The pieces of gamboge are of a yellowish colour externally, and are covered with a yellow powder. Fracture, vitreous or conchoidal, with brown or saffron-yellow colour. At common temperatures, odourless, or nearly so; on heating, gives out a peculiar odour. It is a drastic purgative.

Gamboge dissolves in alcohol, in resins, and in ammonia.

Analyses of Gamboge (Christison).

	Siam				Ceylon Gamboge.	
	Pipe-gamboge.		Cake-gamboge.			
Resin	74·2	71·6	64·3	65·0	68·8	75·5
Gum	21·8	24·0	20·7	19·7	20·7	18·5
Amylaceous matter...	..	...	6·2	5·0	...	...
Woody fibre	...	...	4·4	6·2	6·8	0·6
Moisture	4·8	4·8	4·0	4·6	4·6	4·8
	100·8	100·4	99·6	100·5	100·9	99·3

The resin is easily dissolved out by ether. It has an acid character, decomposing alkaline carbonates at a boiling heat, and forming salts with the alkalies of a red colour.

Saffron.—A yellow substance, consisting of the dried stigmas, with part of the styles, of the saffron crocus (*Crocus sativas*), a plant indigenous to Greece and Asia Minor, and cultivated in Austria, France, and Spain. The length of the stigmas is from 1 to 1½ inch; they are narrow and roundish where attached to the style, but spreading and club-shaped near the extremity, which is truncated. They have an orange or brownish-red colour, yellow in the narrower part; a strongly aromatic, almost intoxicating, odour; an aromatic, bitter taste; and impart a strong yellow colour to the saliva, to water, alcohol, and oils. Strong sulphuric acid colours them first indigo-blue, then red, and finally brown.

It is often adulterated with other substances of similar colour, such as the florets of the safflower or the marigold, but these are easily detected on close examination by their different shape, &c.

Turmeric.—*Syn.* Curcuma, Radix curcuma, Terra merita.—The root of *Amomum curcuma*, cultivated in India and Java. According to PELLETIER and VOGEL, it contains a strong-smelling volatile oil, gum, a yellow colouring matter (CURCUMIN), a brown colouring matter, starch, cellulose, and a small quantity of calcium chloride. It is used for colouring varnishes.

Asphaltum.—*Syn.* ASPHALT, COMPACT BITUMEN, MINERAL PITCH, JEW'S PITCH, FOSSIL BITUMEN, BITUMEN FOSSILE, BITUMEN JUDAICUM, BITUMEN SOLIDUM, BITUMEN VITREUM; MUMIA, MUMIA MINERALIS, L.; ASPHALTE BITUME MASSIF, BITUME SOLIDE, POIX JUIVE (Fr.); ASPHALT, ERDPECH, JUDENPECH (Ger.).—It is a black, hard, brittle, and glossy variety of bitumen, found on the shores of the Dead Sea, on and near the shores of the Great Pitch Lake of Trinidad, and as a mineral product in various other parts of the world.

Melts without decomposition, and, when pure, burns without residue. It is distinguished from other varieties of bitumen by its more difficult fusibility, and by its fracture being clean, conchoidal, and vitreous. Distilled by itself, it yields about 36 per cent. of a peculiar bituminous oil (crude petrolene), together with combustible gases, ammonia, and water. Average sp. gr. from 1· to 1·68. By friction it yields negative electricity. It is soluble in oil of turpentine, benzol, mineral and coal-tar naphtha, fixed oils, and solutions of the caustic alkalies, by the aid of heat.

The finer varieties are chiefly used as a "glazing colour" by artists, and in the manufacture of black varnishes and japans. The Egyptians used it in embalming under the name of *mumia*, and the Babylonian builders are said to have employed it as a cement, in lieu of mortar.

A factitious asphalt is made from the "bottoms" of Barbadoes tar, and other bitumens, by heating them until quite hard; and sometimes a little Scio turpentine, balsam of copaiba, or even common resin is added. Colour, hardness, &c., inferior to native asphalt.

D. CLAYE* recommends the following method for testing the purity of asphaltum:—The mass is dissolved in carbon bisulphide, filtered, evaporated to dryness, and heated until it can be ground to powder in a mortar. 0·1 gm. of the substance thus obtained is treated with 5 c.c. of fuming sulphuric acid for twenty-four hours. It is then mixed with 10 c.c. of water, with continuous stirring. Pure asphalt may be recognized by the light-yellow solution that is obtained, while, when pitch, coal-tar, &c., are present, the solution is of a dark-brown or blackish colour.

Preparation of Varnishes.—To ensure the excellence of oil varnishes, one of the most important points is the use of good drying oil. Linseed oil for this purpose should be very pale, perfectly limpid or transparent, scarcely odorous, and mellow and sweet to the taste. 100 galls. of such an oil are put into an iron or copper boiler capable of holding fully 150 galls., gradually heated to a gentle simmer, and kept near that point for about two hours, to expel moisture; the scum is then carefully removed, and 14 lb. of finely pulverized scale litharge, 12 lb. of red lead, and 8 lb. of powdered umber (all carefully dried and free from moisture) are gradually sprinkled in; the whole is then kept well stirred, to prevent the driers sinking to the bottom, and the boiling is continued at a gentle heat for about three hours longer; the fire is next withdrawn, and, after thirty to forty hours' repose, the scum is carefully removed, and the clear supernatant oil decanted from the "bottoms." The product forms the best boiled or drying oil of the varnish-maker. Another method is to heat a hogshead of the oil gradually for two hours, then to gently simmer it for about three hours longer, and, after removing the scum, to add, gradually, 1 lb. of the best calcined magnesia, observing to mix it up well with the oil, and afterwards to continue the boiling pretty briskly for at least an hour, with constant agitation. The fire is then allowed to die away, and, after twenty-four hours, the oil is decanted as before. The product is called "clarified oil," and requires to be used with driers. It should be allowed to lie in the cistern for two or three months to clarify.

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* "J. Soc. Chem. Ind." 1882, 203.

In the preparation of oil varnishes, the gum is melted as rapidly as possible, without discolouring or burning it; and, when completely fused, the oil, also heated to nearly the boiling point, is poured in, after which the mixture is boiled until it appears perfectly homogeneous and clear, like oil, when the heat is raised, the driers (if any are to be used) gradually and cautiously sprinkled in, and the boiling continued, with constant stirring, for three or four hours, or until a little, when cooled on a palette-knife, feels strong and stringy between the fingers. The mixture is next allowed to cool considerably, but, while still quite fluid, the turpentine, previously made moderately hot, is cautiously added, and the whole thoroughly incorporated. The varnish is then run through a filter or sieve into stone jars, cans, or other vessels, and set aside to clarify itself by subsidence. When no driers are used, the mixture of oil and gum is boiled until it runs perfectly clear, when it is removed from the fire, and, after it has cooled a little, the turpentine is added as before.

It is generally conceived that the more perfectly the gum is fused, or run, as it is called, the larger and stronger will be the product; and the longer the boiling of the "gum" and oil is continued, within moderation, the freer the resulting varnish will work and cover. An excess of heat renders the varnish stringy, and injures its flowing qualities. For pale varnishes, as little heat as possible should be employed throughout the whole process. Good body varnishes should contain 1½ lb.; carriage, wainscot, and mahogany varnish, fully 1 lb.; and gold size and black japan, fully ½ lb. of gum per gall., besides the asphaltum in the latter. Spirit varnishes should contain about 2½ lb. of gum per gall. The use of too much driers is found to injure the brilliancy and transparency of the varnish. Copperas does not combine with varnish, but only hardens it; sugar of lead, however, dissolves in it to a greater or less extent. Boiling oil of turpentine combines very readily with melted copal, and it is an improvement on the common process, to use it either before or in conjunction with the oil, in the preparation of copal varnish that it is desired should be very white. Gums of difficult solubility are rendered more soluble by being exposed, in the state of powder, for some time to the air.

Varnishes, like wines, improve by age; and should always be kept as long as possible before use.

From the inflammable nature of the materials of which varnishes are composed, their manufacture should be only carried on in some detached building of little value, and built of uninflammable materials. When a pot of varnish, gum, or turpentine catches fire, it is most readily extinguished by closely covering it with a piece of stout woollen carpeting, which should be always kept at hand, ready for the purpose.

In the preparation of spirit varnishes care should be taken to prevent the evaporation of the alcohol as much as possible, and also to preserve the portion that evaporates. On the large scale, a common still may be advantageously employed; the head being furnished with a stuffing-box, to permit of the passage of a vertical rod, connected with a stirrer at one end and a working handle at the other. The gum and spirit being introduced, the head of the still closely fitted on and luted, and the connection made with a proper refrigerator, heat (preferably that of steam or a water-bath) should be applied, and the spirit brought to a gentle boil, after which it should be partially withdrawn, and agitation continued until the gum is dissolved. The spirit which has distilled over should be then added to the varnish, and after thorough admixture the whole should be run off, as rapidly as possible, through a silk-gauze sieve, into stone jars, which should be immediately corked down, and set aside to clarify. On the small scale, spirit varnishes are best made by maceration in closed bottles or tin cans, either in the cold or by the heat of a water-bath. In order to prevent the agglutination of the resin, it is often advantageously mixed with clean siliceous sand or pounded glass, by which the surface is much increased, and the solvent power of the menstruum greatly promoted.

A writer in the "Chemical Review"* points out that the chief properties to be sought in a varnish are (*a*) good working, (*b*) hard drying and free rubbing, and (*c*) non-liability to crack, but that these qualities are so closely connected with one another that a superior excellence in one respect is only obtained at the expense of a corresponding deterioration in another, and that, consequently, it is impossible to make a varnish which shall excel in every respect.

Application of Varnishes.—To give the highest degree of lustre to varnish after it is laid on, as well as to remove the marks of the brush, it is necessary to polish. This is performed by first rubbing it with very finely powdered pumice-stone and water, and afterwards with an oiled rag and tripoli, until the required polish is produced. The surface is last of all cleaned with soft linen cloths, cleared of all greasiness with powdered starch, and then rubbed bright with the palm of the hand.

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* May 1882; "J. Soc. Chem. Ind." 1882, 181.

In applying a varnish, care must be taken that the surface is free from grease or smoke, as, unless this is the case, the best oil or turpentine varnish in the world will not dry and harden. Old articles are usually washed with soap and water by painters before being varnished, to prevent any failure of the kind alluded to.

Japanning is the art of covering paper, wood, or metal with a coating of hard, brilliant, and durable varnish. The varnishes or lacquers employed for this purpose in Japan, China, and the Indian Archipelago are resinous juices derived from various trees belonging to the natural order *Anacardiaceæ*, especially *Stagmaria verniciflua*, *Holigarna longifolia*, *Semicarpus anarcardium*, and species of *Rhus* (sumach). For use, they are purified by defecation and straining, and are afterwards mixed with a little oil and colouring matter, as required. In this country varnishes of amber, asphaltum, or copal, or mixtures of them, pass under the name of " japan," or " japan varnish."

In the process of japanning, the surface is coloured or painted with devices, &c., as desired; next covered with a highly transparent varnish (amber or copal), then dried at a high temperature (135° to 165° F.), and lastly, polished. Wood and paper are first sized, polished, and then varnished. For plain surface, asphaltum varnish or japan is used.

Formulæ :—**Amber Varnish.**—*Prep.* 1. Take of amber (clear and pale), 6 lb.; fuse it, add of hot clarified linseed oil, 2 galls.; boil until it "strings well," then let it cool a little, and add of oil of turpentine, 4 galls. or q. s. Nearly as pale as copal varnish; it soon becomes very hard, and is the most durable of the oil varnishes; but it requires some time before it is fit for polishing, unless the articles are "stoved." When required to dry and harden quicker, drying oil may be substituted for the linseed oil, or "driers" may be added during the boiling.

2. Amber, 4 oz.; pale boiled oil, 1 quart; proceed as last. Very hard.

3. Pale transparent amber, 5 oz.; clarified linseed oil or pale boiled oil, and oil of turpentine, of each 1 pint; as before.

Amber varnish is suited for all purposes where a very hard and durable oil varnish is required. The paler kind is superior to copal varnish, and is often mixed with the latter to increase its hardness and durability. The only objection to it is the difficulty of preparing it of a very pale colour. It may, however, be easily bleached with some fresh-slaked lime.

Balloon Varnish.—*See* FLEXIBLE VARNISH (*below*).

Bessemer's Varnish.—This consists of a pale oil copal varnish, diluted with about 6 times its volume of oil of turpentine, the mixture being subsequently agitated with about 1–30th part of dry slaked lime, and decanted after a few days' repose. Five parts of the product mixed with four parts of bronze powder form "Bessemer's gold paint."

Black Varnish.—*Prep.* 1. (BLACK AMBER VARNISH.) From amber, 1 lb.; fuse, add of hot drying oil, ½ pint; powdered black resin, 3 oz.; asphaltum (Naples), 4 oz.; when properly incorporated and considerably cooled, add of oil of turpentine, 1 pint. This is the beautiful black varnish of the coachmakers.

2. (IRONWORK BLACK.) From asphaltum, 48 lb.; fuse, add of boiled oil, 10 galls.; red lead and litharge, of each 7 lb.; dried and powdered white copperas, 3 lb.; boil for two hours, then add of dark gum amber (fused), 8 lb.; hot linseed oil, 2 galls.; boil for two hours longer, or until a little of the mass, when cooled, may be rolled into pills, then withdraw the heat, and afterwards thin it down with oil of turpentine, 30 galls. Used for the ironwork of carriages, and other nice purposes.

3. (Black japan, Bituminous varnish.) *a.* From Naples asphaltum, 50 lb.; dark gum animé, 8 lb.; fuse, add of linseed oil, 12 galls.; boil as before, then add of dark gum amber, 10 lb., previously fused and boiled with linseed oil, 2 galls.; next add of driers, q. s., and further proceed as ordered in No. 2. Excellent for either wood or metals.

b. From burnt umber, 8 oz.; true asphaltum, 4 oz.; boiled linseed oil, 1 gall.; grind the umber with a little of the oil; add it to the asphaltum, previously dissolved in a small quantity of the oil by heat; mix, add the remainder of the oil, boil, cool, and thin with a sufficient quantity of oil of turpentine. Flexible.

4. (Brunswick black.) *a.* To asphalt, 2 lb., fused in an iron pot, add of hot boiled oil, 1 pint; mix well, remove the pot from the fire, and, when cooled a little, add of oil of turpentine, 2 quarts. Used to blacken and polish grates and ironwork. Some makers add driers.

b. From black pitch and gas-tar asphaltum, of each 25 lb.; boil gently for five hours, then add of linseed oil, 8 galls.; litharge and red lead, of each 10 lb.; boil as before, and thin with oil of turpentine, 20 galls. Cheaper than the last, but inferior.

Body Varnish.—*Prep.* 1. From the finest African copal, 8 lb.; drying oil, 2 galls.; oil of turpentine, 3½ galls.; proceed as for Amber varnish. Very hard and durable.

2. Pale gum copal, 8 lb.; clarified oil, 2 galls.; dried sugar of lead, ¼ lb.; oil of turpentine, 3½ galls.; proceed as before, and mix the product, whilst still hot, with the following varnish:—Pale gum animé, 8 lb.; linseed oil, 2 galls.; dried white copperas, ¼ lb.; oil of turpentine, 3½ galls.; the mixed varnishes are to be immediately strained into the cans or cistern. Dries in about six hours in winter, and in about four hours in summer. Used for the bodies of coaches and other vehicles.

Bookbinder's Varnish.—*Prep.* Take of pale gum sandarach, 3 oz.; rectified spirit, 1 pint; dissolve by cold digestion and frequent agitation. Used by binders to varnish morocco leather book-covers. A similar varnish is also prepared from very pale shell-lac and wood naphtha.

Cabinet-maker's Varnish.—French polish is occasionally so called.

Carriage Varnish.—*Prep.* 1. (SPIRIT.) Take of gum sandarach, 1¼ lb.; very pale shell-lac, ¾ lb.; very pale transparent resin, ½ lb.; rectified spirit of ·8221 (64 o.p.), 3 quarts; dissolve, and add of pure Canada balsam, 1½ lb. Used for the internal parts of carriages, &c. Dries in ten minutes or less.

2. (OIL.) *a.* (Best pale.) Take of pale African copal, 8 lb.; fuse, add of clarified linseed oil, 2½ galls.; boil until very stringy, then add dried copperas and litharge, of each ¼ lb.; again boil, thin with oil of turpentine, 5½ galls.; mix, whilst both are hot, with the following varnish, and immediately strain the mixture into a covered vessel:—Gum animé, 8 lb.; clarified linseed oil, 2½ galls.; dried sugar of lead and litharge, of each ¼ lb.; boil as before, thin with oil of turpentine, 5½ galls. Dries in four hours in summer, and six in winter. Used for the wheels, springs, &c., of coaches and other vehicles, and by house painters, decorators, and others who want a strong, quick-drying, and durable varnish.

b. (Second quality.) From gum animé ("sorts"), 8 lb.; clarified oil, 3 galls.; litharge, 5 oz.; dried and powdered sugar of lead and white copperas, of each 4 oz.; boil as last, and thin with oil of turpentine, 5½ galls. Used as the last.

Chinese Varnish.—*Prep.* From mastic and sandarach, of each 2 oz.; rectified spirit (64 o.p.), 1 pint; dissolve. Dries in six minutes. Very tough and brilliant.

Copal Varnish.—*Prep.* 1. (OIL.) *a.* From pale hard copal, 2 lb.; fuse, add of hot drying oil, 1 pint; boil as before directed, and thin with oil of turpentine, 3 pints or q. s. Dries hard in twelve to twenty-four hours.

b. From clear and pale African copal, 8 lb.; pale drying oil, 2 galls.; rectified oil of turpentine, 3 galls.; proceed as before, and immediately strain it into the store can or cistern. Very fine, hard, and durable.

2. (SPIRIT.) *a.* From coarsely powdered copal and glass, of each 4 oz.; alcohol of 90 per cent. (64 o.p.), 1 pint; camphor, ½ oz.; heat the mixture, with frequent stirring, in a water-bath, so that the bubbles may be counted as they rise until solution is complete, and, when cold, decant the clear portion.

b. From copal (which has been melted, dropped into water, and then dried and powdered), 4 oz.; gum sandarach, 6 oz.; mastic, 2 oz.; pure Chio turpentine, 3 oz.; powdered glass, 5 oz.; spirit of 90 per cent., 1 quart; dissolve by a gentle heat. Dries rapidly.

3. (TURPENTINE.) To oil of turpentine, 1 pint, heated in a water-bath, add, in small portions at a time, of powdered copal (prepared as above), 3 to 4 oz.; dissolve, &c., as before. Dries slowly, but is very pale and durable.

4. (JAPANNER'S COPAL VARNISH.) From pale African copal, 7 lb.; pale drying oil, ½ gall.; oil of turpentine, 3 galls.; proceed as in No. 1. Dries in twenty to sixty minutes, and may be polished as soon as hard, particularly if stoved. (*See* JAPANNING, p. 335.)

All copal varnishes, when properly made, are very hard and durable, though less so than those of amber; but they have the advantage over the latter of being paler. They are applied on coaches, pictures, polished metal, wood, and other objects requiring a good durable varnish. Animé is frequently substituted for copal in the copal varnishes of the shops.

Crystal Varnish.—*Prep.* 1. From genuine pale Canada balsam and rectified oil of turpentine, equal parts. Used for maps, prints, drawings, and other articles of paper, and also to prepare tracing-paper, and to transfer engravings.

2. Mastic, 3 oz.; rectified spirit, 1 pint; dissolve. Used to fix pencil drawings.

Drying Varnish.—Spirit copal varnish.

Dutch Varnish.—Lac and toy varnishes are often so called.

Etching Varnish.—White wax, 2 oz.; black and Burgundy pitch, of each ½ oz.; melt together; add by degrees powdered asphaltum, 2 oz., and boil till a drop taken out on a plate will break when bent backwards and forwards several times. Next pour into warm water, and roll into small balls.

Flexible Varnish.—*Syn.* BALLOON VARNISH, CAOUTCHOUC V., INDIA-RUBBER V.—*Prep.* 1. From india-rubber (cut small), 1½ oz.; chloroform, ether (washed), or bisulphide of carbon, 1 pint; digest in the cold until solution is complete. Dries as soon as it is laid on. Pure gutta-percha may be substituted for india-rubber.

2. India-rubber, in shavings, 1 oz.; rectified mineral naphtha or benzol, 1 pint; digest at a gentle heat in a closed vessel, and strain. Dries very badly, and never gets perfectly hard.

3 India-rubber, 1 oz.; drying oil, 1 quart; dissolve by heat. Very tough; dries in about forty-eight hours.

4. Linseed oil, 1 gall.; dried white copperas and sugar of lead, of each 3 oz.; litharge, 8 oz.; boil, with constant agitation, until it strings well, then cool slowly, and decant the clear portion. If too thick, thin it down with quick-drying linseed oil. The above are used for balloons, gas-bags, &c.

Furniture Varnish.—1. A solution of pure white wax, 1 part, in rectified oil of turpentine, 4 parts, frequently passes under this name. (*See* BODY, CARRIAGE, and COPAL VARNISHES, &c.)

2. Olive oil, 9 parts; oil of amber, rectified, 9 parts; oil of turpentine, 9 parts; tincture of alkanet, 1 part; mix, and keep in a well-stoppered bottle. When using it, pour a little upon a pellet of cotton, apply it lightly to the wood several times, and then rub it dry with a cotton rag. If the polish of the furniture has only faded, it will be entirely restored. Of course, if the surface has been rendered rough, or has been scratched, it must first be restored to its former smoothness.[*]

Gilder's Varnish.—*Prep.* (WATIN). Pale gum-lac in grains, gamboge, dragon's-blood, and annotta, of each 12½ oz.; saffron, 3¼ oz.; dissolve each resin separately in 5 pints of alcohol of 90 per cent., and make two separate tinctures of the dragon's-blood and annotta, with a like quantity of spirit; then mix the solutions in the proper proportions to produce the required shade. Used for gilded articles, &c.

Glass Varnish.—A solution of soluble glass. Used to render wood, &c., fire-proof.

Gun-barrel Varnish.—*Prep.* From shell-lac, 1½ oz.; dragon's-blood, 3 drs.; rectified spirit, 1 quart. Applied after the barrels are "browned."

Hair Varnish.—*Prep.* From hog's bristles (chopped small), 1 part; drying oil, 10 parts; dissolve by heat. Said to be used to give cotton or linen cloth the appearance of horse-hair.

India-rubber Varnish.—*See* FLEXIBLE (*above*).

Italian Varnish.—*Prep.* Boil Scio turpentine until brittle, powder it, and dissolve this in oil of turpentine. Used for prints, &c.

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[*] "Year Book of Pharmacy," 1883, 322.

Japan Varnish.—Pale amber or copal varnish. Used for japanning tin, papier-maché, &c.

Label Varnish.*—Sandarach, 53 parts; mastic, 20 parts; camphor, 1 part; oil of lavender, 8 parts; Venice turpentine, 4 parts; ether, 6 parts; alcohol, 40 parts. Macerate for several weeks, agitating frequently until dissolved, and decant, or strain, from impurities. The varnish dries rapidly to a colourless, smooth, and glossy layer.

Lac Varnish.—*Prep.* 1. Pale seed-lac (or shell-lac), 8 oz.; rectified spirit, 1 quart; dissolve.

2. Substitute lac bleached with chlorine for seed-lac. Both are very tough, hard, and durable, but quite inflexible. Wood naphtha may be substituted for spirit. Used for pictures, metal, wood, or leather, and particularly for toys.

Lac Varnish (Aqueous).—*Prep.* From pale shell-lac, 5 oz.; borax, 1 oz.; water, 1 pint; digest at nearly the boiling point until dissolved, then strain. Equal to the more costly spirit varnish for many purposes; it is an excellent vehicle for water-colours, inks, &c.; when dry, it is waterproof.

Lac Varnish (Coloured).—*Syn.* LACQUER, BRASSWORK VARNISH.—*Prep.* 1. Take of turmeric (ground), 1 lb.; rectified spirit, 2 galls.; macerate for a week, strain, with expression, and add to the tincture, gamboge, 1½ oz.; pale shell-lac, ¾ lb.; gum sandarach, 3½ lb. When dissolved, strain, and further add of good turpentine varnish, 1 quart. Gold coloured.

2. Seed-lac, 3 oz.; turmeric, 1 oz.; dragon's-blood, ¼ oz.; rectified spirit, 1 pint; digest for a week, frequently shaking, then decant the clear portion. Deep gold coloured.

3. Spanish annotta, 3 lb.; dragon's-blood, 1 lb.; gum

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* "Rundschau," 1882, 686; "Year Book of Pharmacy," 1883, 321.

sandarach, 3¼ lb.; rectified spirit, 2 galls.; turpentine varnish, 1 quart; as before. Red coloured.

4. Gamboge, 1 oz.; Cape aloes, 3 oz.; pale shell-lac, 1 lb.; rectified spirit, 2 galls.; as before. Pale brass-coloured.

5. Seed-lac, dragon's-blood, annotta, and gamboge, of each ¼ lb.; gum sandarach, 2 oz.; saffron, 1 oz.; rectified spirit, 1 gall. Resembles the last.

Lacquer.—A solution of shell-lac in alcohol, tinged with saffron, annotta, aloes, or other colouring substances. It is applied to wood and metals to impart a golden colour.

Mahogany Varnish.—*Prep.* From gum animé ("sorts"), 8 lb.; clarified oil, 3 galls.; litharge and powdered dried sugar of lead, of each ¼ lb.; proceed as for body varnish, and thin with oil of turpentine, 5 galls. or q. s.

Maps, Varnish for.—A varnish for paper which produces no stains may be prepared as follows:—Clear dammar resin is covered, in a flask, with four and a half to six times its quantity of acetone, and allowed to stand for fourteen days at a moderate temperature, after which the clear solution is poured off. Three parts of this solution are then mixed with four parts of thick collodion, and the mixture allowed to become clear by standing. It is applied with a soft camel's-hair or beaver's-hair brush in vertical strokes. At first the coating looks like a thin white film; but, on complete drying, it becomes transparent and shining. It should be laid on two or three times. It retains its elasticity under all circumstances, and remains glossy in every kind of weather.*

Mastic Varnish.—*Syn.* PICTURE VARNISH, TURPENTINE V, TINGRY'S ESSENCE V.—*Prep.* 1. Take of pale and picked gum mastic, 5 lb.; glass (pounded as small as barley, and well washed and dried), 3 lb.; finest newly rectified oil of turpentine (lukewarm), 2 galls.; put them into a clean 4-gall. tin bottle or can, bung down securely, and keep rolling it backwards and forwards pretty smartly on a counter, or any other solid place, for at least four hours, when, if the gum is all dissolved, the varnish may be decanted, strained through muslin into another bottle, and allowed to settle; if the solution is still incomplete, the agitation must be continued for some time longer, or gentle warmth applied as well. Very fine.

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* "J. Soc. Chem. Ind." 1882, 180.

2. (Second quality.) From mastic, 4 lb.; oil of turpentine, 2 galls. Dissolve with heat.

Mastic varnish is much used for pictures, &c.; when good, it is tough, hard, brilliant, and colourless. It greatly improves by age, and, when possible, should never be used before it has been made at least a twelvemonth. Should it get "chilled," 1 lb. of well-washed siliceous sand should be made moderately hot and added to each gallon, which must then be well agitated for five minutes, and afterwards allowed to settle.

Oak Varnish.—*Syn.* WAINSCOT VARNISH, COMMON TURPENTINE V.—*Prep.* 1. Clear pale resin, 3½ lb.; oil of turpentine, 1 gall.; dissolve.

2. To the last add of Canada balsam, 1 pint. Both are cheap and excellent common varnishes for wood or metal.

Oil Varnish.—The finer qualities are noticed under AMBER, BODY, CARRIAGE, and COPAL VARNISH. The following produces the ordinary oil varnish of the shops:—Take of good clear resin, 3 lb.; drying oil, ½ gall.; melt, and thin with oil of turpentine, 2 quarts. A good and durable varnish for common work.

Painter's Varnish.—*See* CARRIAGE, COPAL, MAHOGANY, OAK, and other varnishes, the selection depending greatly on the colour and quality of the work.

Patent Leather Varnish.—This is carefully prepared drying oil. The skins being stretched on a board, and every trace of grease being removed from them by means of a mixture of fuller's earth and water, they are ready to receive the varnish, which is then spread upon them very thinly by means of a species of scraper. The first-coat varnish consists of pale Prussian blue (that containing some alumina), 5 oz.; drying oil, 1 gall.; boiled to the consistence of single size and, when cold, ground with a little vegetable black; it is stoved, and afterwards polished with fine-grained pumice. The second coating resembles the first, excepting in having a little pure Prussian blue mixed with it. The third-coat varnish consists of a similar mixture, but the oil is boiled until it strings well, and a little more pure Prussian blue and vegetable black are added. The last-coat varnish, or finish, is the same as the third, but must contain ½ lb. of pure dark-coloured Prussian blue and ¼ lb. of pure vegetable black per gall., to which a little oil copal or amber varnish is often added, each coat being duly stoved and pumiced before the next is applied. The heat of the stove or oven is commonly 120° F. for "enamelled skins," as those of the calf and seal, intended for "uppers;" and 175° to 180° for stout "japan leather;" the exposure in the stove is commonly for six to ten hours. The skins are next oiled and grained. The "graining" of the "enamelled skins" is done by holding the skin in one hand, and with a curved board lined with cork (graining stick), lightly pressed upon the fleshy side, working it up and down until the proper effect is produced.

Photographic Varnishes.—Mr. W. Bedford recommends the following negative varnish:—"Button" lac, ½ lb.; sandarach, 2 oz.; methylated spirit, ½ gall. Shake up occasionally during a week, by which time the soluble portion will be taken up, but avoid heat, as it is better to filter off the sediment. "Button" lac, though apparently browner than shell-lac, is recommended in preference, as it really gives a lighter coloured solution; but even seed-lac may be used if the precaution be taken, after filtration, of boiling the clear, but dark-coloured, varnish for ten minutes in a flask on a water-bath, with 4 oz. of freshly prepared animal charcoal. This treatment, followed by a second filtration, effectually removes the orange dye, which would otherwise tend to retard the printing. Another negative varnish is prepared from gum-juniper, 2 drs.; gum frankincense, 1 dr.; alcohol, 4 oz. Filter through paper, and use the clear solution.

*Varnish for Dry-plates.**—Red shell-lac varnish, ½ pint; methylated spirit, about 1½ pint. Try a plate, and add or lessen spirit according to requirements.

*Varnish for Wet-plate Negatives.**—White hard varnish, ½ pint; methylated spirit, about 1 pint. Try plate; if too thick, add more spirit. A capital varnish for retouching purposes.

*Fritz Luckhardt's Retouching Varnish.**—Alcohol, 300 parts; sandarach, 50 parts; camphor, 5 parts; castor oil, 10 parts; Venetian turpentine, 5 parts.

*Varnish to imitate Ground Glass.**—Sandarach, 18 parts; mastic, 4 parts; ether, 200 parts; benzol, 80 to 100 parts.

Varnish for backing Positives.—Spirits of turpentine, 6 oz.; asphaltum, 2 oz.; white wax, 2 scruples; lampblack, 1½ scruple. Dissolve in a warm place, and filter through flannel.

Picture Varnish.—Several varnishes, especially mastic varnish, are called by this name. Pale copal or mastic varnish is generally used for oil paintings, and crystal, white hard spirit, or mastic varnish for water-colour drawings on paper.

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* "Year Book of Photography," 1885.

Resist Varnish.—Used in electro-plating for keeping off deposits where not required. Resin or copal dissolved in boiled linseed or oil of turpentine, and coloured with red lead, chrome yellow, or Prussian blue.

Sealing-wax Varnish.—Black, red, or any coloured sealing-wax, broken small, with enough rectified spirit (or methylated spirit) to cover it, digested till dissolved. A most useful varnish for woodwork of electrical or chemical apparatus, for tops of corks, &c.

Spirit Varnish.—*Prep.* 1. (BROWN HARD.) *a.* From gum sandarach, 3 lb.; pale seed-lac or shell-lac, 2 lb.; rectified spirit (65 o.p.), 2 galls.; dissolve, and add of turpentine varnish, 1 quart; agitate well, strain (quickly) through gauze, and in a month decant the clear portion from the sediment. Very fine.

b. From seed-lac and yellow resin, of each 1½ lb.; rectified spirit, 5 quarts; oil of turpentine, 1¼ pint; dissolve. Inferior to the last.

2. (WHITE HARD.) *a.* From gum sandarach (picked), 5 lb.; camphor, 2 oz.; washed and dried coarsely pounded glass, 3 lb.; rectified spirit (65 o.p.), 7 quarts; proceed as in making mastic varnish; when strained, add of pure Canada balsam, 1 quart. Very pale, durable, and brilliant.

b. From gum sandarach and gum mastic, of each, picked, 4 oz.; coarsely powdered glass, 8 oz.; rectified spirit, 1 quart; dissolve, and add of pure Strasburg turpentine, 3 oz. Very fine.

3. (SOFT BRILLIANT.) From sandarach, 6 oz.; elemi (genuine), 4 oz.; animé, 1 oz.; camphor, ½ oz.; rectified spirit, 1 quart; as before.

4. (SCENTED.) To the preceding add some gum benzoin, balsam of Peru, balsam of Tolu, oil of lavender, or the essence of musk or ambergris. The first two can only be employed for dark varnishes.

Spirit varnishes are chiefly applied to articles of the toilette, as work-boxes, card-cases, &c., but are also suitable for other articles, whether of paper, wood, linen, or metal, that require a brilliant and quick-drying varnish. They dry almost as soon as applied, and are usually hard enough to polish in twenty-four hours. They are, however, much less durable, and more liable to crack, than oil varnishes.

Stopping-out Varnish.—*Syn.* PETIT VERNIS, Fr.—From lampblack, made into a paste with turpentine. Used by engravers.

Tingry's Varnish.—*See* MASTIC VARNISH.

Toy Varnish.—Similar to common spirit varnish, but using carefully rectified wood naphtha as the solvent. (*See* LAC and SPIRIT VARNISHES.)

Transfer Varnish.—*Syn.* MORDANT VARNISH.—*Prep.* From mastic (in tears) and sandarach, of each 4 oz.; rectified spirit, 1½ pint; dissolve, and add of pure Canada balsam, ½ pint. Used for transferring and fixing engravings or lithographs on wood, and for gilding, silvering, &c. (*See* CRYSTAL VARNISH.)

Turpentine Varnish.—*See* MASTIC and OAK VARNISHES.

Universal Lacquer.—*Prep.* Bleached shell-lac, 60 parts; Manilla copal (freshly powdered), 60 parts; gum mastic, 60 parts, are mixed with 1000 parts of alcohol (92 to 95 per cent.); a small quantity of coarsely powdered glass is added, and the whole left to stand for eight to fourteen days, frequently shaking; 1 part of boracic acid is then added, and the mixture filtered.

This lacquer is said to be equally good for paper, metal, wood, glass, &c. It may be coloured with any aniline dye soluble in alcohol.*

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* "Chemist and Druggist," Jan. 1885.

Wainscot Varnish.—*See* OAK VARNISH.

Waterproof Varnish.—Palmitate or oleate of alumina dissolved in petroleum, ether, or benzene. After the evaporation of the solvent, an impermeable varnish is left.* (*See also* NIIN OIL, p. 33.)

Wax Varnish.—*Syn.* MILK OF WAX, EMULSIO CERÆ SPIRITUOSA, L.—*Prep.* 1. Take of white wax (pure), 1 lb.; melt it with as gentle a heat as possible, add of warm rectified spirit, sp. gr. ·830 (60 o.p.), 1 pint; mix perfectly, and pour the liquid out upon a cold porphyry slab; next grind it with a muller to a perfectly smooth paste, adding more spirit as required; put the paste into a marble mortar, make an emulsion with water, 3½ pints, gradually added, and strain it through muslin. Used as a varnish for paintings; when dry, a hot iron is passed over it, or heat is otherwise evenly applied, so as to fuse it and render it transparent, after which, when quite cold, it is polished with a clean linen cloth. The most protective of all varnishes.

2. Wax (pure), 5 oz.; oil of turpentine, 1 quart; dissolve. Used for furniture.

White Varnish.—*See* SPIRIT VARNISH 2, *a* and *b*.

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* Engl. Patent 4921, 1883.

CHAPTER XI.

TESTING RESINS.

I. Mills' Bromine Absorption Process.—Messrs. MILLS and MUTER* have applied their bromine method (*see* p. 251) to the examination of resins. The method of procedure is as follows:—The finely powdered resin is placed overnight (together with the usual 50 c.c. of solvent) in the colorimetric bottles, and the next morning the bromine absorption is carried out. The following are some of the results:—

Varnish Resins

	Absorption.	Remarks.
Shellac, bleached	4·61	S.N. Chiefly insoluble.
Shellac............	5·21	S.N. „ „ [given off.
Gum benzoin ...	38·90	S.N. Partly soluble. Some hydric bromide
Amber	53·53	S.N. „ „ Ditto.
Animé	60·22	S.N. „ „ Much hydric bromide.
Gamboge	71·56	S.N. Chiefly „ Ditto.
Copal, reduced to ¾ by boiling...	84·52	S.N. Partly „ Ditto.
Copal	89·93	S.N. „ „ Ditto.
Sandarac	96·42	S.N. „ „ Very much ditto.
Dammar	117·94	S.N. Wholly „ Much ditto.
Elemi	122·23	S.N. „ „ Very much ditto.
Mastic	124·33	S N. Partly „ Much ditto.

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* "Journ. Soc. Chem. Ind." 1885, 97.

Tinctorial Resins.

	Absorption.	Remarks.
Xanthorrhœa, New Holland	7·11	T.H. Slightly soluble.
Xanthorrhœa	8·33	T.H. Insoluble.
*Calamus	8·37	T.H. "
X. hastilis (grass-tree), Queensland	9·11	T.H. Partially soluble.
Xanthorrhœa, Australia	10·35	T.H. Partially soluble. A little hydric bromide.
*C., Punjaub	10·45	T.H. Insoluble.
*C., Kew	11·97	T.H. "
*Dracæna cinnabari, Socotra	13·81	T.H. "
X. hastilis, Australia	15·68	T.H. "
*C. draco, Bombay	22·01	T.H. "
X. hastilis, Tasmania	30·74	T.H. "
" Sydney	33·25	T.N.
*C. draco, Kew	55·24	T.H. Insoluble. Partly bleached by bromine.
*Sumatra	66·39	T.H. Partly soluble. Partly bleached by bromine.
*C. draco, Singapore	73·81	T.H. Partly bleached.
*Calamus, Menier & Co.	74·58	T.H.
*Dutch E. Indies	81·59	T.H. Insoluble; bleached.
*Sumatra	84·87	T.H. Partly soluble. Partly bleached.

In the above experiments sometimes β-naphthol was used for titrating back, more particularly—as in the case of the pale resins—when the bromine derivatives had but little tint. Sometimes the operation was finished with hyposulphite and deci-normal iodine. All the results are means of at least three determinations. The letters S. and T. indicate that disulphide or tetrachloride was used respectively. The letters N. and H. indicate that the absorption was finally measured by β-naphthol or hyposulphite. The names marked with an asterisk represent commercial varieties of dragon's-blood.

It will be seen that the extraordinarily low absorption of shellac gives it a unique position among resinous bodies, and amber is distinctly below all other substances of its class. As a rule, but not invariably, the more soluble a gum resin, the greater is its bromine absorption.

II.—Hirscholm's Process.*

1. Alcohol (95 per cent.).†

Completely Soluble.

Benzoin
Coniferous resins
Dragon's-blood
Mastic (Alexandrian and Bombay)
Sandarac

Incompletely Soluble.

Copal
Dammar
Elemi
Gamboge
Shellac
Mastic (common)
Lac (Sonora)

2. Ether.

Completely Soluble.

Coniferous resins
Dragon's-blood
Elemi
Mastic
Sandarac

Incompletely Soluble.

Benzoin
Copal
Dammar
Shellac
Gamboge
Lac (Sonora)

3. Ethereal Solution.

With addition of Alcohol.

Clouded.

Copal (Brazilian)
Dammar
Mastic (common)
Lac (Sonora)

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* "Russ. Zeitschr. Pharm." xvi. 1, 33, 65, 97; Watts' "Dict. of Chem." vol. viii. pt. ii. 3rd suppt. 1743.

† This table is not extracted in full, but only so far as relates to the resins usually employed in varnishes.

Clear mixture.

- Benzoin
- Conifer resins
- Copal
- Dragon's-blood
- Elemi
- Shellac
- Gamboge
- Mastic (Alexandrian and Bombay)
- Sandarac

4. Chloroform.

Completely soluble.

- Benzoin
- Conifer resins
- Copal (Brazilian)
- Dammar
- Dragon's-blood (not all varieties)
- Mastic

Incompletely soluble, or not at all.

- Copal
- Dragon's-blood (*Pterocarpus draco*)
- Shellac
- Gamboge
- Sandarac
- Lac (Sonora)

5. Alcoholic Solution.

A. *With addition of Lead Acetate.*

Precipitate does not dissolve, or only partially, on boiling.

- Benzoin
- Conifer resins
- Copal
- Dammar (certain East Indian samples)
- Dragon's-blood (*Pterocarpus draco*)
- Shellac
- Mastic (Bombay)
- Sandarac
- Lac (Sonora)

Precipitate disappears on heating.

- Dammar (certain East Indian samples)
- Mastic (common and Alexandrian)

No turbidity.

- Dammar
- Dragon's-blood (some sorts)
- Elemi
- Gamboge

B. *With addition of Ferric Chloride.*

A turbidity or precipitate which disappears on heating and dissolves in ether.

Dammar (some Indian sorts)

Precipitate does not disappear on heating, nor dissolve in ether.

Copal

Lac (Sonora)

No precipitate, but solution coloured.

(a) ***Black, brown, or greenish-black.***

Gamboge
Shellac

(b) ***Dark-green.***

Benzoin

The other resins are coloured either greenish, or brownish, or not at all.

C. *With addition of Aqueous Ammonia.*

Clear mixture.

Conifer resins (some)
Copal
Dragon's-blood (*Pterocarpus draco*)
Shellac
Gamboge
Sandarac
Lac (Sonora)

Turbid mixture.

The other (varnish) resins

6. Alcohol containing Hydrochloric Acid.

Coloured.

(a) *Blue to violet.*

Elemi

(b) *Yellow, changing through red-brown to cherry-red.*

Benzoin

(c) *Yellow.*

Gamboge

(d) *Brown changing to various shades.*

The remaining (varnish) resins

7. Concentrated Sulphuric Acid.

Dissolves.

1°. *With cherry-red colour.*

Benzoin (Siam)

2°. *Yellow.*

Gamboge

3°. *Brown, changing to various shades.*

Other resins

8. Sulphuric Acid Solution.

A. *With addition of Alcohol.*

1°. *Clear violet.*
Benzoin (Siam and Sumatra)

2°. *Turbid, brown.*
Other resins

B. *With addition of Water.*

Resins thrown down in flocks.

1°. *Violet.*
Benzoin (Siam)

2°. *Dingy red-violet.*
Benzoin (Sumatra)

3°. *Yellow.*
Gamboge

4°. *Brown.*
Other resins

9. Chloroform Extract.

With addition of Bromine Solution.

1°. *Resin thrown down in flocks.*
Shellac
Copal (Australian)

2°. *Brown colour—no flocks.*
Other resins

10. Sodium Carbonate Solution.

A. *At Ordinary Temperatures.*

1°. *Violet.*
Shellac

2°. *Crimson.*
Lac (Sonora)

3°. *Yellowish, or yellow-red.*
Dragon's-blood (*Pterocarpus draco*)
Gamboge

4°. *Yellowish, brownish, or no coloration.*
Other resins

B. *At Boiling Heat.*

1°. *Violet.*
Shellac

2°. *Yellow.*
Benzoin
Dragon's-blood
Sandarac

3°. *Yellowish, brownish, or no coloration.*
Other resins

C *With addition of Acetic Acid at Ordinary Temperatures.*

1°. *Flocks thrown down.*
Conifer resins
Gamboge
Sandarac

2°. *Nothing, or only turbidity.*
Other resins

11. Petroleum Ether Extract.

A.

1°. *Deep yellow.*
Gamboge

2°. *Yellowish, or colourless.*
Other resins

B. *With addition of Iodine Solution.*

1°. *Clear violet.*
Benzoin
Dragon's-blood
Shellac

2°. *Red-violet—clear, becoming turbid.*
Copal
Dammar (some samples)
Mastic
Gamboge
Sandarac

3°. *Brown and turbid mixtures.*
Other resins

C. *Residue after Evaporation.*

(a) *With addition of Sulphuric Acid.*

1°. *Crimson.*
Benzoin (Siam)

2°. *No coloration.*
Shellac

3°. *Yellow, or brown.*
Other resins

(b) *With addition of Chloral Reagent.*

(*I.e.*, an impure chloral hydrate obtained by saturating alcohol with chlorine, mixing the product with 4 vols. strong sulphuric acid, stirring up the solid mass which separates with one-third of its weight of water and distilling.)

1°. *Yellowish, or greenish, changing to red-violet.*
Conifer resins

2°. *Yellow.*
Gamboge

3°. *Green.*
Dammar

4°. *Greenish.*
Benzoin (Sumatra)

5°. *No coloration, or faint.*
Other resins

APPENDIX.

COMPARISON OF FAHRENHEIT AND CENTIGRADE THERMOMETERS.

To convert C. into F. temperatures $\frac{C. \times 9}{5} + 32 = F.$

„ F. „ C. „ $\frac{(F. - 32) \times 5}{9} = C.$

1° F. = 0·555° C.
1° C. = 1·8° F.

F. Degrees.	C. Degrees.	F. Degrees.	C. Degrees.	F. Degrees.	C. Degrees.
0	= − 17·78	70	= 21·11	145	= 62·77
5	− 15·00	75	23·88	150	65·55
10	− 12·22	80	26·67	155	68·32
15	− 9·44	85	29·44	160	71·11
20	− 6·67	90	32·22	165	73·88
25	− 3·88	95	34·99	170	76·66
30	− 1·11	100	37·78	175	79·43
32	0·00	105	40·55	180	82·22
35	1·67	110	43·33	185	84·99
40	4·44	115	46·10	190	87·77
45	7·21	120	48·89	195	90·54
50	10·00	125	51·66	200	93·33
55	12·77	130	54·44	205	96·10
60	15·56	135	57·21	210	98·88
65	18·33	140	60·00	212	100·00

PRICES.

The prices quoted in the following lists are examples of those actually obtained in Mincing Lane for articles sold *in bulk for cash*:—

Oils.		£	s.	d.		£	s.	d.
Seal oil, pale	per tun	25	0	0	to	28	0	0
Sperm oil, body	,,	51	0	0		60	0	0
Cod oil	,,	31	0	0		35	0	0
Cod-liver oil	per gall.	0	3	0		0	6	0
Whale oil, S. Sea, pale	per tun	19	0	0		26	0	0
Olive oil:								
Florence	half-chest	0	8	6		0	17	6
,,	square box	0	13	0		0	14	6
Lucca	per gall.	0	4	0		0	6	6
Gallipoli, f.o.b.	per tun	40	0	0		53	0	0
Sublime	,,	59	0	0		70	0	0
Extra ditto	,,	70	0	0			—	
Cream	,,	80	0	0		82	0	0
Cocoa-nut oil:								
Cochin	per ton	29	10	0		34	0	0
Ceylon	,,	26	0	0		32	0	0
Palm oil:								
Fine Lagos	,,	29	0	0		34	0	0
Whydah	,,	28	0	0		34	0	0
Accra	,,	26	0	0		33	0	0
Palm-nut or copra oil	,,	26	0	0		30	10	0
Linseed oil	,,	19	5	0		22	10	0
Rape-seed oil:								
English refined	,,	22	15	0		27	15	0
Brown	,,	21	0	0		26	0	0
Lard oil, English	,,	34	0	0		41	0	0
Tallow and oleine oil	,,	25	0	0		45	0	0
Cotton oil:								
Refined	,,	17	15	0		26	5	0
Crude	,,	15	15	0		21	10	0
Rangoon engine oil	per gall.	0	2	6		0	3	0
Castor oil, in tins	per lb.	0	0	3		0	0	4
Colza oil	per cwt.	1	4	0		1	8	0
Nut oil:								
French		1	12	0		2	2	0
Gambia	,,	1	18	0			—	
Sesamé oil	,,	1	14	0		1	16	0
Neat's-foot oil	per gall.	0	3	0		0	3	6

PRICES—(*continued*).

Oils.		£	s.	d.		£	s.	d.
Petroleum oil:								
Pennsylvanian	per gall.	0	0	6	to	0	0	7¼
Water-white	”	0	0	7¾		0	0	11
Russian ditto	”	0	0	6½		0	0	8
Petroleum:								
Spirit	”	0	0	6¼		0	0	7⅛
Rectified	”	0	0	7		0	0	8¼
Coal oil, refined	”	0	0	5¾		0	0	6⅛
Lubricating oil, English and foreign	per ton	5	0	0		15	0	0
Paraffin:								
Scale........................	per lb.	0	0	1¼		0	0	4
Wax	”	0	0	4		0	0	6
Tallows.								
P.Y.C.	per cwt.	1	15	0		2	0	0
Australian beef	”	1	0	0		1	14	0
Mutton........................	”	1	2	0		1	14	6
Town	”	1	4	9		1	15	0
Yellow candle	”	1	15	0		2	2	0
Melted stuff..................	”	0	17	0		1	6	0
Rough stuff	”	0	8	9		0	13	3
Town fat	per 8 lb.	0	0	8		0	1	3
Graves	per cwt.	0	9	0		0	16	0
Good dregs	”	0	4	0			—	
Turpentine, American spirits	”	1	1	6		1	8	0
Rosin, American	”	0	2	6		0	14	0
Waxes.								
Bees’:								
Jamaica	”	6	15	0		8	0	0
East India	”	5	5	0		7	12	0
Vegetable, Japan	”	2	12	0		3	3	0
Spermaceti:								
Refined.....................	per lb.	0	1	0			—	
American	”	0	0	10½			—	
Essential Oils.								
Almond..................	”	1	15	0			—	
Anise-seed:								
Star	”	0	6	9		0	7	3
German, &c.	”	0	8	0		0	13	0
Bergamot................ ...	”	0	5	6		0	7	9

PRICES—(*continued*).

Essential Oils.		£	s.	d.		£	s.	d.
Cajuput...	per bot.	0	3	3	to	0	3	4
Caraway	per lb.	0	5	3		0	11	0
Cassia	,,	0	3	6		0	4	0
Cinnamon	per oz.	0	1	6		0	3	6
Cinnamon-leaf	,,	0	0	2		0	0	$2\frac{3}{8}$
Citronelle	,,	0	0	1		0	0	2
Clove............................	por lb.	0	3	3		0	3	6
Juniper...........................	,,	0	1	6		0	2	0
Lavender:								
Exotic	,,	0	6	6		0	8	6
Mitcham	,,	2	0	0		2	10	0
Lemon	,,	0	3	6		0	6	0
Lemon-grass	por oz.	0	0	$1\frac{7}{16}$		0	0	2
Neroli	,,	0	7	0			—	
Nutmeg	,,	0	0	8			—	
Orange	per lb.	0	8	0		0	10	0
Otto of roses	per oz.	0	13	0		1	12	0
Patchouli	,,	0	1	4		0	2	0
Peppermint:								
American	per lb.	0	12	0		0	13	0
H. G. Hotchkiss	,,	0	17	6		0	19	0
English.....................	,,	1	8	0		1	12	6
German......................	,,	0	8	0		0	14	0
Japan	,,	0	10	0		0	17	0
Menthol crystals	,,	0	17	0		2	0	0
Rosemary.....	,,	0	2	6		0	3	9
Sassafras	,,	0	2	6			—	
Spearmint	,,	0	12	0		0	14	0
Thyme	,,	0	1	9		0	2	6
Mace expressed	por oz.	0	0	2			—	
Resins.								
Animé:								
Fine washed...............	per cwt.	14	10	0		22	0	0
Scraped	,,	11	0	0		18	0	0
Mixed	,,	3	0	0		11	0	0
Copal:								
Manilla	,,	0	15	0		3	15	0
Angola, red	,,	7	5	0		7	12	6
Dammar, pale	,,	3	10	0		4	7	6
Dragon's blood...............	,,	3	10	0		12	0	0
Gamboge, pipe...............	,,	10	10	0		15	0	0
Mastic, picked	per lb.	0	1	6		0	3	3
Sandarac	per cwt.	3	0	0		5	5	0
Shellac:								
Orange	,,	2	12	0		4	8	0

PRICES—(*continued*).

		£	s.	d.		£	s.	d.
Resins.								
Shellac:								
Native and liver	per cwt.	2	12	0	to	3	12	0
Garnet and bronze	„	2	14	0		3	10	0
Button sort	„	3	10	0		4	6	0
Varnishes.								
Body	per gall.	0	16	0		0	18	0
Carriage	„	0	12	0		0	14	0
Oak	„	0	5	0		0	8	6
Crystal paper	„	0	7	0		0	8	0
Fine paper	„	0	5	0		0	6	0
Spirit varnishes and French polish	„	0	8	6		0	9	0
Gold size	„	0	5	0		0	7	6
Black japan	„	0	11	0		0	12	0
Brunswick black	„	0	4	6		0	6	0
Terebine	„	0	5	6			—	

QUANTITIES AND VALUES OF OILS IMPORTED DURING 1882, 1883, AND 1884.

Oils.		Quantities.			Values.		
		1882.	1883.	1884.	1882.	1883.	1884.
					£	£	£
Cocoa-nut	cwt.	136,087	210,874	245,695	214,236	365,716	398,488
Olive	tuns.	23,190	30,935	17,201	937,601	1,193,797	715,752
Palm	cwt.	801,545	743,512	825,822	1,220,817	1,304,385	1,385,345
Petroleum	galls.	59,135,384	70,185,563	52,808,436	1,704,753	2,156,235	1,705,773
Seed of all kinds	tuns.	14,620	10,513	12,546	478,208	365,855	384,509
Train, blubber & sperm	„	15,924	16,899	17,525	526,862	596,721	531,421
Turpentine	cwt.	357,878	350,138	462,134	639,685	555,902	559,972

AMOUNT AND VALUE OF EXPORTS OF SEED OILS DURING 1882, 1883, AND 1884.

	1882.		1883.		1884.	
	Gallons.	£	Gallons.	£	Gallons.	£
To Sweden and Norway	538,300	54,932	743,700	67,297	829,800	72,984
To Germany	5,312,400	521,975	8,086,600	707,531	5,612,600	470,671
To Holland...............	1,545,300	152,367	2,471,000	237,797	1,233,200	116,606
To Belgium	384,900	38,018	1,206,200	108,184	458,600	41,338
To France	445,200	46,316	911,800	83,916	662,300	67,445
To Spain and Canaries	306,900	30,655	334,100	29,189	238,500	20,510
To Italy..................	716,100	74,539	843,300	78,447	1,321,100	125,369
To Austrian Territories	649,300	65,390	1,042,300	101,411	1,110,900	108,960
To Egypt	418,700	41,470	373,400	34,094	409,200	37,158
To Brazil	356,100	39,476	389,500	38,291	283,900	26,106
To British N. America	739,900	75,412	913,000	81,830	647,600	54,604
To Australasia	865,200	104,900	859,200	94,440	1,036,200	108,182
To other Countries ...	1,763,600	198,621	1,980,600	201,093	2,206,300	216,002
Total	14,041,900	1,444,071	20,154,700	1,863,520	16,050,200	1,465,935

SUMMARY OF THE PRODUCTION OF OIL SHALE

in the United Kingdom during the last five years, together with the *Average Price per ton of Shale* at the Mines (Mr. JAMES NICOL).

Counties.	1880.	1881.	1882.	1883.	Price per Ton.	1884.	Price per Ton.
	Tons.	Tons.	Tons.	Tons.	*s.* *d.*	Tons.	*s.* *d.*
Edinburgh	372,994	451,018	487,592	458,206	5 0	640,753	5 0
Linlithgow	342,983	353,826	355,700	476,869	5 0	581,121	5 0
Fife	16,418	...	29,856	87,589	5 0	128,996	5 0
Renfrew	56,440	65,379	90,804	82,988	6 0	97,273	5 6
Lanark	28,830	30,293	25,606	16,318	5 0	9,752	5 0
Ayr	6,172	6,533	4,929	4,242	6 0	7,219	5 6
Stirling..........................	...	5,122	...	4,517	5 0	4,535	5 0
Scotland	793,837	912,171	994,487	1,130,729	...	1,469,649	...
England and Wales ...	43,968	46,084	36,428	37,214	6 9½	49,222	6 9½
Total production of oil shale in the United Kingdom	837,805	958,255	1,030,915	1,167,943	...	1,518,871	...

THE PETROLEUM ACT, 1879 (42 & 43 VICT. CAP. 47).

AN ACT TO CONTINUE AND AMEND THE PETROLEUM ACT, 1871.

[*11th August* 1879.]

BE it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

Short title, and construction of Act. 34 & 35 Vict. c. 105.

1. This Act may be cited as the Petroleum Act, 1879.

This Act shall be construed as one with the Petroleum Act, 1871, and together with that Act may be cited as the Petroleum Acts, 1871 and 1879.

Alteration of test. 34 & 35 Vict. c. 105.

2. Whereas by the Petroleum Act, 1871, it is enacted that the term "petroleum to which this Act applies" means such of the petroleum defined by that Act as, when tested in manner set forth in Schedule One to that Act, gives off an inflammable vapour at a temperature of less than one hundred degrees of Fahrenheit's thermometer, and it is expedient to alter the said test: Be it therefore enacted that—

34 & 35 Vict. c. 105.

In the Petroleum Act, 1871, the term "petroleum to which this Act applies" shall mean such of the petroleum defined by section three of that Act as, when tested in manner set forth in Schedule One to this Act (see p. 274), gives off an inflammable vapour at a temperature of less than seventy-three degrees of Fahrenheit's thermometer.

34 & 35 Vict. c. 105.

Every reference in the Petroleum Act, 1871, to Schedule One to that Act shall be construed to refer to Schedule One to this Act.

Verification of test apparatus.

3. A model of the apparatus for testing petroleum, as described in Schedule One to this Act, shall be deposited with the Board of Trade, and the Board of Trade shall, on payment of such fee, not exceeding five shillings, as they from time to time prescribe, cause to be compared with such model and verified every apparatus constructed in accordance with

Schedule One to this Act which is submitted to them for the purpose, and if the same is found correct shall stamp the same with a mark approved of by the Board and notified in the London Gazette.

An apparatus for testing petroleum purporting to be stamped with the said mark shall, until the contrary is proved, be deemed to have been verified by the Board of Trade.

All fees under this section shall be paid into the Exchequer.

Continuance of 34 & 35 Vict. c. 105.

4. The Petroleum Act, 1871, shall continue in force until otherwise directed by Parliament.

Commencement of Act.

5. This Act shall come into operation on the thirty-first day of December one thousand eight hundred and seventy-nine, which day is in this Act referred to as the commencement of this Act.

Repeal of part of 34 & 35 Vict. c. 105.

6. The Petroleum Act, 1871, shall be repealed after the commencement of this Act to the extent in the third column of the Second Schedule to this Act mentioned.

Provided that any sample of petroleum taken before the commencement of this Act shall be tested in manner set forth in Schedule One to the Petroleum Act, 1871, and any offence committed before the commencement of this Act shall be prosecuted, and any investigation, legal proceeding, or remedy in relation to such offence, or to any act done before the commencement of this Act, shall be instituted, carried on, and have effect as if the provisions of this Act, other than those continuing the Petroleum Act, 1871, had not been passed.

34 & 35 Vict. c. 105.

34 & 35 Vict. c. 105.

ADDENDA.

Viscosity of Oils (p. 303).—New forms of apparatus for testing viscosity are described in "Journ. Soc. Chem. Ind." 1886, by Mr. BOVERTON REDWOOD (p. 121) and by Prof. MILLS (p. 148).

Maumené's Test (p. 233).—When a drying oil, or fish oil, is to be examined, Mr. C. J. ELLIS has proposed ("Journ. Soc. Chem. Ind." 1886, p. 150) to dilute the sample, before addition of the acid, with a *mineral* oil the temperature reaction of which has been previously determined, so as to moderate the action and lower the maximum temperature attainable to below 60° or even 50° C. In this way, it is said, the test may be made *quantitative*.

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